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A FORTRAN PROGRAM FOR DETERMINING AIRCRAFT STABILITY AND CONTROL DERIVATIVES FROM FLIGHT DATA

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16. Abstract

A digital computer program written in FORTRAN IV for the estimation of aircraft stability and control derivatives is presented. The program uses a maximum likelihood estimation method. Two associated programs for routine, related data handling are also included. The three programs form a package that can be used by relatively inexperienced personnel to process large amounts of data with a minimum of manpower. This package has been used to successfully analyze 1500 maneuvers on 20 aircraft. It is designed to be used without modification on as many types of computers as feasible. Program listings and sample check cases are included.

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INTRODUCTION

Determination of aircraft stability and control derivatives from flight data is of great importance in flight testing and control system design. Several methods have been used, but recent interest has turned toward maximum likelihood estimators. In addition to producing the "best" possible estimates as defined by some probabilistic criterion, these methods can be automated to a large extent.

Experience at the NASA Flight Research Center has shown that derivatives can be extracted with minimum effort by relatively inexperienced personnel using maximum likelihood estimators. Others have had some difficulty, perhaps partially due to inadequately designed programs. A production version of a maximum likelihood estimation program has been developed and used at the Flight Research Center to determine aircraft stability and control derivatives from large amounts of flight data. The program was designed to be compatible with as many types of computers as feasible and was structured to accommodate alterations easily. The program is applicable to many linear parameter estimation problems, although several of the features are intended specifically for aircraft stability and control applications. Reference 1 discusses an earlier program from which this maximum likelihood estimation program was conceptually derived.

This report presents the modified maximum likelihood estimation computer program used at the Flight Research Center for derivative extraction as well as associated programs for table lookup of initial estimates of the derivatives and for plotting results. Program listings and sample check cases for each program are included in the appendixes.

SYMBOLS

Parenthetical symbols are computer identifiers for data channels.

A	stability matrix, or axial force (appendix E)

a_n (AN)	vertical acceleration, g
a_x (AX)	longitudinal acceleration, g
a_y (AY)	lateral acceleration, g
B	control matrix
C_m	dimensionless pitching-moment coefficient
C_n	dimensionless yawing-moment coefficient
C_Z	dimensionless normal-force coefficient
c	vector of unknowns
c_0	*a priori* value of c
$D1$	signal weighting matrix
$D2$	*a priori* weighting matrix
$E[\ ]$	expected value
E_k	relative error
G	observation matrix
g	acceleration of gravity, m/sec^2 (ft/sec^2)
H	observation matrix
I	identity matrix
I_X	moment of inertia about the longitudinal axis, kg-m^2 (slug-ft^2)
I_{XZ}	cross-product of inertia about the longitudinal and normal axes, kg-m^2 (slug-ft^2)
I_Z	moment of inertia about the normal axis, kg-m^2 (slug-ft^2)
i	time index
J	cost functional

L	rolling moment divided by moment of inertia about longitudinal axis, rad/sec^2
$L_0, L_{0_2}, L_{0_3}, L_{0_4}$	rolling acceleration equation biases
M	pitching moment divided by moment of inertia about lateral axis, rad/sec^2
$M_0, M_{0_2}, M_{0_3}, M_{0_4}$	pitching acceleration equation biases
N	yawing moment divided by moment of inertia about normal axis, rad/sec^2, or number of time points
$N_0, N_{0_2}, N_{0_3}, N_{0_4}$	yawing acceleration equation biases
p (P)	roll rate, deg/sec or rad/sec
q (Q)	pitch rate, deg/sec or rad/sec
$\bar{q}$	dynamic pressure, N/m^2 (lb/ft^2)
R	acceleration transformation matrix
r (R)	yaw rate, deg/sec or rad/sec
S	reference area, m^2 (ft^2)
s	auxiliary time variable, sec
T	total time, sec
t	time, sec
Δt	time interval between samples, sec
u	control vector
V	velocity, m/sec (ft/sec)
ν	variable bias vector
W	aircraft weight, N (lb)
X	longitudinal force divided by mass, m/sec^2 (ft/sec^2)
$X_0, X_{0_2}, X_{0_3}, X_{0_4}$	longitudinal acceleration equation biases

x	state vector
Y	side force divided by mass and velocity, rad/sec
$Y_0, Y_{0_2}, Y_{0_3}, Y_{0_4}$	side force equation biases
y	computed observation vector
Z	normal force divided by mass and velocity, rad/sec
$Z_0, Z_{0_2}, Z_{0_3}, Z_{0_4}$	normal force equation biases
z	measured observation vector
α (A)	angle of attack, deg or rad
β (B)	angle of sideslip, deg or rad
δ	control, deg or rad
δ_a (DA)	aileron position, deg or rad
$\delta_c, \delta_1, \delta_2$ (DC,D1,D2)	extra controls, deg or rad
δ_e (DE)	elevator position, deg or rad
δ_r (DR)	rudder position, deg or rad
η	noise vector
θ (THET)	pitch attitude, deg or rad
$\dot{\theta}_0, \dot{\theta}_{0_2}, \dot{\theta}_{0_3}, \dot{\theta}_{0_4}$	biases in Euler pitch rate equation
τ	revised time interval, sec
φ (PHI)	Euler roll attitude, deg or rad
$\dot{\varphi}_0, \dot{\varphi}_{0_2}, \dot{\varphi}_{0_3}, \dot{\varphi}_{0_4}$	biases in Euler roll rate equation

∇_c	gradient with respect to c
∇_c^2	second gradient with respect to c (Hessian matrix)
$\mathbf{0}$	null matrix

Superscript:

$*$	transpose

Subscripts:

$p,q,r,V,\alpha,\beta,$ $\delta_a,\delta_c,\delta_e,$ $\delta_r,\delta_1,\delta_2$	partial derivatives with respect to the subscripted variable
i,k	i^{th} and k^{th} elements of vector or matrix
L	iteration number
0	constant value

A dot over a quantity denotes the time derivative of that quantity.

PARAMETER ESTIMATION

The problem considered is: Given a set of flight time histories of an aircraft's response variables, find the values of some unknown parameters in the system equations that best represent the actual aircraft response. An intuitive mathematical approach to this problem would be to minimize the difference between the flight response and the response computed from the system equations. This difference could be defined for each response variable as the integral of the error squared. These signal errors could then be multiplied by weighting factors and summed to obtain the total response error, thereby defining an integral squared error criterion.

A mathematically more precise formulation can be made in probabilistic terms. For each possible estimate of the unknown parameters, a probability that the aircraft response time histories take on the values actually observed can be defined. The estimates should be chosen so that this probability is maximized. This process is referred to as a maximum likelihood formulation of the problem. Maximum likelihood estimators have many desirable characteristics; for example, they yield asymptotically unbiased and consistent estimates. If the measurement noise is assumed to be Gaussian, white, stationary, and uncorrelated, this formulation is equivalent to a response error formulation, in which the weightings used are the inverse of the measurement noise covariance matrix.

To mathematically describe the maximum likelihood estimator it is first necessary to define the equations of motion for the aircraft system. These equations are:

$$R\dot{x}(t) = Ax(t) + Bu(t) \tag{1}$$

$$y(t) = \left[\frac{I}{G}\right]x(t) + \left[\frac{\mathbf{0}}{H}\right]u(t) + \left[\frac{\mathbf{0}}{\nu}\right] \tag{2}$$

$$z(t) = y(t) + \eta(t) \tag{3}$$

where

x	state vector
u	control vector
ν	bias vector
y	computed observation vector
z	measured observation vector
η	noise vector

For the aircraft problem being considered, it is convenient to separate the equations of motion into longitudinal and lateral-directional sets. The linearized longitudinal equations are:

$$\frac{d}{dt}\begin{bmatrix} \alpha \\ q \\ V \\ \theta \end{bmatrix} = \begin{bmatrix} Z_\alpha & 1 & Z_V & -\sin(\theta)\cos(\varphi)\frac{g}{V} \\ M_\alpha & M_q & M_V & 0 \\ X_\alpha & 0 & X_V & -\cos(\theta)g \\ 0 & \cos(\varphi) & 0 & 0 \end{bmatrix}\begin{bmatrix} \alpha \\ q \\ V \\ \theta \end{bmatrix} + \begin{bmatrix} Z_{\delta_e} & Z_{\delta_c} & Z_{\delta_1} & Z_{\delta_2} & Z_0 \\ M_{\delta_e} & M_{\delta_c} & M_{\delta_1} & M_{\delta_2} & M_0 \\ X_{\delta_e} & X_{\delta_c} & X_{\delta_1} & X_{\delta_2} & X_0 \\ 0 & 0 & 0 & 0 & \dot{\theta}_0 \end{bmatrix}\begin{bmatrix} \delta_e \\ \delta_c \\ \delta_1 \\ \delta_2 \\ 1 \end{bmatrix} \tag{4}$$

$$a_n = -\frac{V}{g}\left[\dot{\alpha} - q + \sin(\theta)\cos(\varphi)\frac{g}{V}\theta\right] + a_{n_{bias}} \tag{5}$$

The linearized lateral-directional equations are:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & -\frac{I_{XZ}}{I_X} & 0 \\ 0 & -\frac{I_{XZ}}{I_Z} & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\frac{d}{dt}\begin{bmatrix} \beta \\ p \\ r \\ \varphi \end{bmatrix} = \begin{bmatrix} Y_\beta & \sin(\alpha) & -\cos(\alpha) & \cos(\varphi)\cos(\theta)\frac{g}{V} \\ L_\beta & L_p & L_r & 0 \\ N_\beta & N_p & N_r & 0 \\ 0 & 1 & \cos(\varphi)\tan(\theta) & 0 \end{bmatrix}\begin{bmatrix} \beta \\ p \\ r \\ \varphi \end{bmatrix} + \begin{bmatrix} Y_{\delta_a} & Y_{\delta_r} & Y_{\delta_1} & Y_{\delta_2} & Y_0 \\ L_{\delta_a} & L_{\delta_r} & L_{\delta_1} & L_{\delta_2} & L_0 \\ N_{\delta_a} & N_{\delta_r} & N_{\delta_1} & N_{\delta_2} & N_0 \\ 0 & 0 & 0 & 0 & \dot{\varphi}_0 \end{bmatrix}\begin{bmatrix} \delta_a \\ \delta_r \\ \delta_1 \\ \delta_2 \\ 1 \end{bmatrix} \tag{6}$$

$$a_y = \frac{V}{g}\left[\dot{\beta} - \sin(\alpha)p + \cos(\alpha)r - \cos(\varphi)\cos(\theta)\frac{g}{V}\varphi\right] + a_{y_{bias}} \tag{7}$$

The unknown parameters are contained in the matrices A, B, G, and H and in the bias vector, ν. For notational simplicity, the unknown parameters will be regarded as forming a vector c. Then A, B, G, H, and ν are functions of c. There is no provision for modeling state noise, that is, random or unknown inputs to the system such as turbulence. (This problem is treated in reference 2.) Instead, it is assumed that noise is introduced only in the measurement process. It is also assumed that there is no noise in the control measurements.

The integral squared error criterion can now be expressed as finding the vector of unknowns, c, that minimizes the cost functional:

$$J = \frac{1}{T} \int_0^T \left[z(t) - y(t)\right]^* D1\left[z(t) - y(t)\right] dt \tag{8}$$

or as approximated in the discrete case:

$$J = \frac{1}{(N - 1)} \sum_{i=1}^{N} \left(z_i - y_i\right)^* D1\left(z_i - y_i\right) \tag{9}$$

where $D1$ is the symmetric, non-negative definite weighting matrix, i is a time index, and N is the number of time points. The cost functional, J, can also be called the index of performance or the fit error.

SOLUTION BY THE MODIFIED NEWTON-RAPHSON METHOD

Several algorithms for the minimization of nonlinear functionals exist that could be used to minimize J. The modified Newton-Raphson method has proved to be the most suitable for aircraft derivative determination, both in terms of computer time and convergence properties.

The Newton-Raphson algorithm is an iterative method of functional minimization which requires some initial estimate of c and a means of computing the first and second gradients of J with respect to c. Revised estimates of c are then obtained from the equation

$$c_L = c_{L-1} - \left(\nabla_c^2 J\right)_L^{-1} \left(\nabla_c J\right)_L^* \tag{10}$$

where L denotes the iteration number, ∇_c indicates the gradient with respect to c, and ∇_c^2 indicates the second gradient. The first and second gradients of J are then

$$\nabla_c J = \frac{2}{(N - 1)} \sum_{i=1}^{N} \left(z_i - y_i\right)^* D1\, \nabla_c\left(z_i - y_i\right) \tag{11}$$

$$\nabla_c^2 J = \frac{2}{N-1} \sum_{i=1}^{N} \nabla_c(z_i - y_i)^* D1\, \nabla_c(z_i - y_i) + \frac{2}{(N-1)} \sum_{i=1}^{N} (z_i - y_i)^* D1\, \nabla_c^2(z_i - y_i) \quad (12)$$

Computation of $\nabla_c(z_i - y_i)$ is relatively straightforward, as described in reference 3. Computation of $\nabla_c^2(z_i - y_i)$ is much more time consuming; however, Balakrishnan shows in reference 4 that the contribution of this term to the second gradient goes to zero as the process converges. Thus, if we neglect this term, the method is still an asymptotically unbiased estimator. The Newton-Raphson algorithm with this term neglected is referred to as the modified Newton-Raphson algorithm and provides the same result as obtained by quasilinearization.

Reference 1 describes a modification in the computation of the gradient that is used on the first iteration. This modification, analogous to linear least squares, helps to obtain convergence when the initial estimates are far from the minimum. With this modification it is often possible to start with estimates of zero for all the unknowns and still converge to the correct solution.

INCLUSION OF *A PRIORI* INFORMATION

Information from wind tunnel studies, previous flight tests, and other sources (referred to collectively as predicted derivatives) is often available on the values of some of the aircraft derivatives. It may be desirable to include this information in the program's algorithm. The use of this information is particularly important when there is a linear dependence or near dependence of the effect of several derivatives, for instance, in a maneuver in which the control motion is due largely or solely to a feedback of the states. The second gradient matrix then becomes ill-conditioned, resulting in poor convergence properties and unreliable estimates. In most instances a true minimum of the cost functional is still approached, despite the ill conditioning. The location of this minimum may not be important, however, because the linearly dependent derivatives could be altered greatly without significantly increasing the cost. In this instance the slight improvement in the fit obtained by altering the derivatives would not seem sufficient justification for altering them from the *a priori* values.

One solution to this problem would be to add to the cost functional a quadratic penalty function for departure from the *a priori* values. The cost functional, J, would then be

$$J = \frac{1}{(N-1)} \sum_{i=1}^{N} (z_i - y_i)^* D1(z_i - y_i) + (c - c_0)^* D2(c - c_0) \quad (13)$$

where c_0 is the *a priori* estimate, and $D2$ is a symmetric, non-negative definite weighting matrix. The algorithm with this penalty function will be referred to as the modified maximum likelihood estimator. It is important in this formulation for the elements of $D2$ to be small enough that, in general, $\left(c - c_0\right)^* D2\left(c - c_0\right)$ is significantly less than $\frac{1}{(N - 1)} \sum_{i=1}^{N} \left(z_i - y_i\right)^* D1\left(z_i - y_i\right)$. Thus the estimates of those parameters that are well defined by the response data will not be altered.

The first and second gradients of J now become

$$\nabla_c J = \frac{2}{(N - 1)} \sum_{i=1}^{N} \left(z_i - y_i\right)^* D1 \, \nabla_c\left(z_i - y_i\right) + 2\left(c - c_0\right)^* D2 \tag{14}$$

$$\nabla_c^2 J = \frac{2}{(N - 1)} \sum_{i=1}^{N} \nabla_c\left(z_i - y_i\right)^* D1 \, \nabla_c\left(z_i - y_i\right) + 2\, D2 \tag{15}$$

where the second term of equation (12) has been neglected.

When this feature is used, convergence is generally improved. With small enough values of $D2$, the estimates of the derivatives are not affected when the maneuver is well conditioned, but poorly conditioned maneuvers may converge and reveal some information instead of diverging.

CONFIDENCE LEVELS

One advantage of using a maximum likelihood estimator to determine aircraft stability and control derivatives is that an objective measure of the validity of the estimates is obtainable. With some other methods the main criterion of the validity of an estimate is the engineer's subjective judgment.

If the noise obeys the stated assumptions and $D1$ is, in fact, the inverse of the noise covariance matrix, the Cramèr-Rao inequality (ref. 3) gives a lower bound on the covariance matrix of the estimates as follows:

$$E\left[\left(c - c_0\right)\left(c - c_0\right)^*\right] \geq \left[\sum_{i=1}^{N} \nabla_c\left(z_i - y_i\right)^* D1 \, \nabla_c\left(z_i - y_i\right)\right]^{-1} \tag{16}$$

The right side of this inequality is recognized as $\left(\nabla_c^2 J\right)^{-1}$ evaluated without the term for *a priori*. This expression is available in the minimization algorithm (eq. (12)), so these confidence levels (sometimes referred to in the literature as uncertainty levels) may be obtained with little additional effort. They can be useful in assessing the validity of the estimates obtained even when the noise characteristics are different from those assumed.

DESCRIPTION AND USE OF PROGRAMS

A basic computer program and two associated programs form a package that has been used at the NASA Flight Research Center to successfully analyze 1500 maneuvers from 20 aircraft. The basic program, referred to as the modified maximum likelihood estimation program, or MMLE, is designed to obtain maximum likelihood estimates from flight data. The associated programs, SETUP and SUMARY, although not directly related to the mathematical aspects of parameter estimation, have proved useful in extracting aircraft derivatives. The programs are designed to be used easily with the longitudinal and lateral equations of motion (eqs. (4) to (7)) by applying appropriate default values. For the options in the programs, the values designated as defaults are used only if no other values are specified. Each program is discussed in detail in the following sections.

In these programs a general matrix storage convention that permits flexibility and error checking is used. Each matrix is dimensioned with a fixed number of rows, MAX. The last row of the matrix, however, contains information about the matrix, instead of containing matrix elements. The first number in the last row is the number of rows of the matrix that are used; the second number is the number of columns used; and the third element is the matrix name in A format. For example, a 19 by 4 matrix called XJI could be stored in an array dimensioned 35 by 8 as:

	4 columns	4 columns
19 rows	Matrix elements	Unused
15 rows	Unused	Unused
Last row	19. 4. XJI	Unused

This convention permits a variable-size matrix to be stored in an array of fixed dimension. The matrix manipulation subroutines can also check matrix compatibility by examining the last row before performing operations.

The programs use a standard matrix input format which facilitates data checking. The first card of any matrix to be input is a header card containing the name of the matrix, left-justified, in columns 1 to 4, the number of rows in the matrix, right-justified, in columns 9 to 10, and the number of columns in the matrix, right-justified, in columns 11 to 20. The body of the matrix follows, one row to a card, in an 8F10 format.

Additionally, the abbreviation T is used to denote true and F to denote false. NAMELIST variables follow the FORTRAN convention for type (names beginning with I, J, K, L, M, or N indicate integer variables; all other names indicate real variables), unless stated otherwise. Exceptions to this convention are given in parentheses after the NAMELIST variable.

MMLE — MODIFIED MAXIMUM LIKELIHOOD ESTIMATION PROGRAM

The MMLE program can be run on most large modern computers with FORTRAN IV compilers. Approximately $31{,}000_{10}$ words of core storage are required. If overlay or segmentation is used, this requirement can be reduced to about $22{,}000_{10}$. Overlay and segmentation, however, are machine specific; directives for segmenting the MMLE program on the CDC OPERATING SYSTEM SCOPE 3.4 (ref. 5) are included in appendix A (p. 92) and can be used as a guide for implementation on other systems. Some form of automatic plotting equipment is desirable. The MMLE program plotting routines are written for a CalComp pen plotter (ref. 6). If other plotting equipment is used, it may be necessary to modify the plotting routines. The user must verify whether the routines supplied are compatible with the system being used.

From 4000 to 20,000 words of temporary disk storage are required, depending on the number of data points. This requirement is doubled if plots are made. A tape drive (two if plots are desired) may be substituted for disk storage.

Two types of input data are required for the MMLE program. The measured values contained in time histories of a flight maneuver must be available on cards, tape, or a disk file. These time histories are limited by dimensions in the plotting routines to 1000 time points per maneuver; these dimensions may be changed easily. In addition, the program must be provided information on the flight condition of the maneuver, values of pertinent characteristics of the aircraft, a set of starting estimates of the derivatives, and instructions controlling the activation of different program options.

Listings of the MMLE program and its subroutines are given in appendix A. A sample case is presented in appendix B.

Input Description

The inputs required for the MMLE program are described in this section. Each program option is explained immediately after the description of the input that controls the option.

Title card.— The title card contains any information needed to identify a particular set of data that is appropriate to include in the printed and plotted MMLE output. All 80 columns on this card may be used.

NAMELIST/INPUT/.— (See appropriate FORTRAN reference manuals for the format for specific machines.) The parameters included in the NAMELIST are as follows:

(1) LONG, LATR-(logical) — type of aerodynamic mode to be analyzed. The mode type is indicated by LONG = T or LATR = T for longitudinal or lateral-directional, respectively. Only one type should be set. If neither is set, the type

is determined from the A matrix: LONG if A(1,2) > +0.5, LATR otherwise. This element is usually +1 in a longitudinal case or sin (ALPHA) in a lateral-directional case.

Items (2) to (11) are related to the input time histories. The signals which are input from the time histories fall into three classes: observations, controls, and extra. The observations form a vector, z, seven words long; the controls form a vector, u, four words long; and the extra signals form a vector four words long of quantities not actually used in the estimation process but useful in evaluating the quality of the maneuver. For a longitudinal case,

$$z = \begin{bmatrix} \alpha & q & V & \theta & a_n & \dot{q} & a_x \end{bmatrix}^* \tag{17}$$

$$u = \begin{bmatrix} \delta_e & \delta_c & \delta_1 & \delta_2 \end{bmatrix}^* \tag{18}$$

$$\text{Extra} = \begin{bmatrix} \varphi & \text{Altitude} & \text{Mach number} & \bar{q} \end{bmatrix}^* \tag{19}$$

and for a lateral-directional case,

$$z = \begin{bmatrix} \beta & p & r & \varphi & a_y & \dot{p} & \dot{r} \end{bmatrix}^* \tag{20}$$

$$u = \begin{bmatrix} \delta_a & \delta_r & \delta_1 & \delta_2 \end{bmatrix}^* \tag{21}$$

$$\text{Extra} = \begin{bmatrix} \alpha & V & \text{Mach number} & \bar{q} \end{bmatrix}^* \tag{22}$$

(2) CARD, TAPE-(logical) – input source for time histories. Set either CARD = T or TAPE = T. Only one of the two variables can be set to true in the NAMELIST. Default condition is TAPE = T.

(3) SPS – sample rate of input time histories (samples per second). If SPS is not set, a default value is computed from the times shown on the time histories. The times of the first two data points are subtracted and the difference rounded to the nearest 5 milliseconds. The reciprocal of this value is then used as the default value for SPS.

(4) THIN-(integer) – thinning factor for input data. If THIN = 1, every point on the file is used; if THIN = 2, every second point is used, and so forth. SPS is the sampling rate of the data before this thinning. Default value of 1 is used.

(5) NCASE – number of disjoint maneuvers to be used in obtaining one set of estimates. If two or more maneuvers were performed at approximately the same flight condition, they may be processed together to obtain a single set of estimates. Each interval will be weighted by the number of time points in the interval. Default value of 1 is used.

(6) SCALE-(seven-word vector) – scale factor for observations. The observations are multiplied by corresponding elements of SCALE when read in to compensate for any scaling errors or sign changes. Default sets all elements of the vector to 1.0.

(7) FIXED-(seven-word vector) — fixed biases for observations. The known biases are added to the corresponding observations after scaling (item (6)) but before any other operations with the data. Default sets all elements of the vector to 0.

(8) DC-(four-word vector) — known biases for controls. These biases are added to the corresponding controls before any operations with the controls. Default sets all elements of the vector to 0.

(9) NREC — number of data words in each record on input tape. This parameter has no meaning if card input is used. The total number of words in each record should be at least NREC + 4, because the first four words in the record contain the time (hours, minutes, seconds, milliseconds) and are not counted as data words. (See data file input section, p. 24.) NREC is limited by program dimensions to ≤100. Default value of 15 is used unless BOTH = T (item (11)); then the value of 25 is used instead.

(10) ORDER-(15-word integer vector) — location of desired signals on input tape. This parameter has no meaning if card input is used. The signals z, u, and extra are considered to form a single vector of signals, and ORDER describes a mapping of the data record from the tape onto this vector. The I^{th} word in the resulting vector is set equal to the ORDER (I) data word in the tape record. (The first four words in the tape record contain the time and are not counted as data words.) The default is ORDER (I) = I for I = 1, 2, . . .15, which implies that there is no reordering from the input tape to the program.

(11) BOTH-(logical) — special signal order with both longitudinal and lateral-directional data on the tape. This parameter has no meaning if card input is used. If BOTH = T, the input tape is assumed to contain all the data, both longitudinal and lateral-directional, in a specific order. This order is α, q, V, θ, a_n, $\dot{q}$, a_x, δ_e, δ_c, δ_1, δ_2, φ, altitude, Mach number, $\bar{q}$, β, p, r, a_y, $\dot{p}$, $\dot{r}$, δ_a, δ_r, $\delta_{1_{lateral}}$, and $\delta_{2_{lateral}}$, where normally all angular measurements are in degrees, accelerations in g units, and velocities in feet per second. Also, if BOTH = T, NREC is overridden and set to 25; if the case is lateral-directional, the ORDER array is automatically set to [16 17 18 12 19 20 21 22 23 24 25 1 3 14 15], which overrides any order that may have been read in. Thus if the tape has data in the proper order, BOTH may be set to T and the program will automatically pick off the appropriate signals for the type of case being analyzed. Default condition is F.

Items (12) to (18) specify the form of the plotted output.

(12) PLOTEM-(logical) — time history plots comparing measured and estimated response produced if PLOTEM = T. If PLOTEM = F, no plots are made. If the *a priori* variation option (item (53)) is activated, the related derivative plots will be made instead. Default condition is T.

(13) PLTMAX — maximum error for plotting. If the error sum, J, of the last or next to last iteration is greater than PLTMAX, time history plots are not made, even

if PLOTEM = T, to avoid exceeding reasonable plotter limits. Instead, the measured time histories are printed to provide hints about the presumed problem. PLTMAX may not be larger than ERRMAX (item (22)) or it will be set equal to ERRMAX by the program. Default value of $1. \times 10^5$ is used.

(14) INCH-(logical) – plots scaled for inch grid paper if INCH = T; otherwise, for centimeter grid paper. Default condition is F.

(15) ZMIN, ZMAX-(seven-word vectors) – minimum and maximum values on vertical axis for plots comparing measured and estimated observations. The axes are 4 centimeters long (2 inches if INCH = T). If corresponding elements of ZMIN and ZMAX are equal for any signal, automatic scaling will be used on that signal. Default values are all 0 (which implies that automatic scaling is used for the default, since ZMIN = ZMAX).

(16) DCMIN, DCMAX-(eight-word vectors) – minimum and maximum values on vertical axes for plots of controls and extra signals. The comments about ZMIN and ZMAX (item (15)) apply. In addition, if automatic scaling is used for a signal and there is no nonzero point on that signal, the plot of the signal will be omitted. Default values of 0 are used.

(17) NCPLOT – number of controls and extra signals for plotting. Only the first NCPLOT controls and extra signals will be plotted in addition to the observations. This option may be used to reduce plotting of data that may be extraneous for some cases. The value of NCPLOT must be between 1 and 8, inclusive. Default value of 8 is used.

(18) TIMESC – time scale for plots in seconds per centimeter (or seconds per half inch if INCH = T). Default value of 1. is used.

(19) PRINT-(logical) – time histories based on measured data and final computed time histories printed if PRINT = T. Default condition is F.

(20) TEST-(logical) – extra output printed each iteration if TEST = T to facilitate debugging. Extra output includes time histories (in radians), the transition matrix (ref. 8) and its integral, and the first and second gradients of J. Default condition is F.

(21) NOITER – number of iterations desired. NOITER = 0 is defined as a special case for which the program computes the final time histories using initial estimates of the unknown coefficients; that is, the parameter estimation step is omitted entirely. The measured time histories are always printed when NOITER = 0, regardless of the value of PRINT (item (19)). Default value of 6 is used.

(22) ERRMAX – maximum allowable error sum. If the error sum, J, at any time becomes greater than ERRMAX, this is taken as an indication that the process is not converging properly. Therefore, iteration will stop and the measured time histories will be printed to provide clues to the reason for the problem. Default value of $1. \times 10^{20}$ is used.

(23) BOUND – convergence bound. If the error sum, J, in any iteration changes by less than BOUND times the error of the previous iteration, the process is assumed to have converged and iteration is stopped. Default value of 0.001 is used.

(24) PUNCH-(logical) – punched card output of nondimensional estimates. If PUNCH = T, the final estimates of the nondimensional derivatives are punched on cards along with the confidence levels obtained from the Cramèr-Rao bound. Default condition is F.

(25) PUNCHD-(logical) – punched card output of dimensional estimates. If PUNCHD = T, the final dimensional A and B matrices are punched on cards. These cards can be used to restart the program from the final values. Default condition is F.

(26) NEAT – number of time reductions in computation of transition matrix, $e^{A\Delta t}$, and its integral. In typical aircraft uses, a direct series evaluation of $e^{A\Delta t}$ may become computationally unstable for sample rates less than about 10 samples per second. In such cases, the power series evaluation has been used to compute $e^{A\tau}$ and its integral, with $\tau = \frac{\Delta t}{2^{\text{NEAT}}}$. The desired transition matrices are then obtained after recursive applications of the formulas:

$$e^{At} = \left[e^{(At)/2}\right]^2 \tag{23}$$

$$\int_0^t e^{As}ds = \left[e^{(At)/2} + I\right]\int_0^{t/2} e^{As}ds \tag{24}$$

This process provides improved computational stability without increased time or complexity. In general, NEAT should be large enough to make $\tau \leq 0.05$ second. NEAT = 0 implies direct series computation. Default value of 0 is used.

Items (27) to (48) are related to the geometry of the aircraft and the flight condition. Items (28) to (35) are required only if nondimensional derivatives are of interest. If these items are not entered, very large values of all nondimensional derivatives will be printed as a result of the default values to avoid accidental use of the meaningless nondimensional coefficients.

(27) METRIC-(logical) – unit designation for aircraft data. If METRIC = T, all units are standard SI (MKS) units (meter, kilogram, second); otherwise, U.S. Customary (EGS) units are assumed. Default condition is F. All input data units must be consistent with the system specified.

(28) GROSWT – aircraft gross weight (pounds or newtons). Default value of $1. \times 10^9$ is used.

(29) IX-(real) — moment of inertia about the X-axis. This parameter is not needed for longitudinal cases (slug-ft^2 or kg-m^2). Default value of 1. $\times$ 10^9 is used.

(30) IY-(real) — moment of inertia about the Y-axis. This parameter is not needed for lateral-directional cases (slug-ft^2 or kg-m^2). Default value of 1. $\times$ 10^9 is used.

(31) IZ-(real) — moment of inertia about the Z-axis. This parameter is not needed for longitudinal cases (slug-ft^2 or kg-m^2). Default value of 1. $\times$ 10^9 is used.

(32) IXZ-(real) — cross-product of inertia between X- and Z-axes. This parameter is not needed for longitudinal cases (slug-ft^2 or kg-m^2). Default value of 0 is used.

(33) SPAN — wing span (ft or m). Default value of 0.001 is used.

(34) CBAR — reference chord (ft or m). Default value of 0.001 is used.

(35) S — reference wing area (ft^2 or m^2). Default value of 0.001 is used.

Items (36) to (42) concern instrument locations relative to the center of gravity. Angle-of-attack and angle-of-sideslip vane readings are corrected to the center of gravity by using the angular rates. The system model includes an arbitrary accelerometer location, so that accelerations need not be corrected to the center of gravity. The longitudinal axis locations are positive for instruments forward of the center of gravity, and the normal axis locations are positive for instruments below the center of gravity. All values are in feet or meters, and a default value of 0 is used.

(36) XB — location of angle-of-sideslip vane along the longitudinal axis.

(37) XALF — location of angle-of-attack vane along the longitudinal axis.

(38) ZB — location of angle-of-sideslip vane along the normal axis.

(39) XAY — location of a_y accelerometer along the longitudinal axis.

(40) ZAY — location of a_y accelerometer along the normal axis.

(41) XAN — location of a_n accelerometer along the longitudinal axis.

(42) ZAX — location of a_x accelerometer along the normal axis.

Items (43) to (46) are not used in the estimation process, but are useful for identifying the flight condition of the maneuver. They are passed to the SUMARY program for plot identification purposes.

(43) CG — aircraft center of gravity in fraction of chord. Default value of 0.25 is used.

(44) MACH-(real) — average Mach number. If 0, this parameter will be obtained from the input time history. Default value of 0 is used.

(45) ALPHA — average angle of attack. If 999., this parameter will be obtained from the input time history. Default value of 999. is used.

(46) PARAM — any other parameter that might be used to distinguish between flight conditions. PARAM may be used as flap position or wing sweep. Default value of 0 is used.

(47) Q — average dynamic pressure. If 0, this parameter is obtained from the input time history (lb/ft^2 or N/m^2). Default value of 0 is used.

(48) V — average velocity. If 0, this parameter is obtained from the input time history (ft/sec or m/sec). Default value of 0 is used.

(49) VAR-(three-word logical vector) — option that controls variable bias. The fifth to seventh signals of the observation vector have an unknown bias that is included in the system model. (See p. 12 for the elements of the observation vector.) This bias is determined if the corresponding elements of VAR are T. The initial values of these variable biases are 0, except for the a_n bias in a longitudinal case, which starts with a value of 1. The bias on a signal that has a D1 weighting of 0 cannot be determined; therefore, any attempt to determine a bias for an unweighted signal will be overridden in the program. Default sets all elements of the vector to T.

(50) ZERO-(four-word logical vector) — option that requires the program to determine variable initial condition. For each element of ZERO that is T, a variable increment to the initial condition is determined for the corresponding state. This increment is added to the measured initial condition to obtain the initial condition used for the computed data. If the variable initial condition is used in conjunction with NCASE > 1 (item (5)), the same increment from the measured value is used for each maneuver in the case. Default sets all elements of the vector to F.

(51) ND1, D1RLX, D1TOL — parameters that affect diagonal D1 determination option. This puts the program into a different mode of operation. A D1 weighting matrix (see matrix input section) should be determined for each airplane at the beginning of its flight program. This option automatically determines the diagonal elements of the D1 matrix based on a particular case and is activated if ND1 > 0. The program executes one run with the initial D1 matrix (described on p. 23) input, or its default, and then applies a simple iterative algorithm ND1 times to determine the proper D1 matrix. Each iteration of this algorithm involves another run through the estimation loop to obtain a set of weighted relative errors ($E_k = \frac{D1_{kk}}{t} \int_0^t \left[z_k(t) - y_k(t)\right]^2 dt$). The algorithm is designed to find a D1 matrix that results in the weighted error being approximately 1 on each signal being used (as indicated by a nonzero initial estimate of the corresponding D1 element). The motivation for this procedure is discussed in reference 3. The revised estimate of each diagonal element of the D1 matrix is then produced by multiplying the previous estimate by a factor that depends on the previous weighted error of that signal, E_k, and a relaxation factor,

D1RLX. If $E_k \geq 1$, the factor is $\frac{1}{(E_k - 1)\text{D1RLX} + 1}$; and if $E_k < 1$, the factor is $\left(\frac{1}{E_k} - 1\right)\text{D1RLX} + 1$. The variable D1TOL will stop this process if the process has converged before ND1 iterations. If, after any iteration, none of the weighted errors are greater than D1TOL or less than $\frac{1}{\text{D1TOL}}$, a final iteration will be run, and the process will be stopped. The parameter WMAPR (item (52)) will be set to 0 if this option is used, regardless of the MMLE program's input value. If plotting was specified (item (12)), only the time history using the final D1 vector will be plotted. If both the D1 vector determination and the *a priori* variation (item (53)) are activated, the D1 vector will be determined first, and the *a priori* variation will use the final D1 matrix. Default values used are ND1 = 0, D1RLX = 1.2, and D1TOL = 1.4.

Items (52) and (53) are related to the *a priori* feature.

(52) WMAPR – overall weighting factor for *a priori* information. Each element in the *a priori* weighting matrices APRA and APRB (see matrix input section) is multiplied by WMAPR before use. A value of 0 implies that the *a priori* feature is not used in the estimation process. Default value of 0 is used.

(53) NAPR, WFAC – parameters that control *a priori* variation option which puts the program into a different mode. If the *a priori* feature is used, a set of *a priori* weighting matrices should be selected at the beginning of the flight program for each aircraft analyzed. In determining the best weighting matrices to use, it is useful to run the same case with several values of WMAPR (item (52)). Reference 3 describes this process. The option to vary the value of WMAPR is activated if NAPR is greater than 0. The program then runs the entire case a total of NAPR times with different values of WMAPR. The first run is with WMAPR = 0, and the second run is with the value specified for WMAPR by item (52) (if 0 was specified, 0.001 is used instead). For each subsequent run, the value of WMAPR used is WFAC times the value used on the previous run. Time history plots are never produced when this option is used; instead, if PLOTEM = T (item (12)), the final estimates of each of the derivatives are plotted versus WMAPR on a logarithmic scale. The *a priori* estimates, which may be considered as the estimates obtained as WMAPR approaches infinity, are also plotted to the right of the other estimates. These plots may then be used as described in references 3 and 8 to estimate the best values to use for the *a priori* weightings. For these plots to be correct, the NAMELIST variable PUNCH (item (24)) must equal F, because of the order in which the computations are performed. Default values of WFAC = 100. and NAPR = 0 are used.

Time cards.– For each of the NCASE (NAMELIST item (5)) time segments to be included, one time card is required. The time cards contain the start and end times for the segment expressed as hours, minutes, seconds, and milliseconds in the format (2(3I2,I3,1X)). The program starts the segment at the first time point greater than or equal to the start time and stops it at the last point less than or equal to the stop time.

Matrix input.– Several input matrices are read next in a standard matrix input format. The matrices may be read in any order. Only the A and B matrices must be read in; the others may be read in if the default values are to be changed.

A matrix (4 by 4): The A matrix is the starting estimate of the stability matrix. For a longitudinal three-degree-of-freedom case it should be:

$$\begin{bmatrix} Z_\alpha & 1. & Z_V & -\sin(\theta)\cos(\varphi)\frac{g}{V} \\ M_\alpha & M_q & M_V & 0. \\ X_\alpha & 0. & X_V & -\cos(\theta)g \\ 0. & \cos(\varphi) & 0. & 0. \end{bmatrix}$$

In a two-degree-of-freedom case the third column should be set to 0. For a lateral-directional case the A matrix should be:

$$\begin{bmatrix} Y_\beta & \sin(\alpha) & -\cos(\alpha) & \cos(\varphi)\cos(\theta)\frac{g}{V} \\ L_\beta & L_p & L_r & 0. \\ N_\beta & N_p & N_r & 0. \\ 0. & 1. & \cos(\varphi)\tan(\theta) & 0. \end{bmatrix}$$

Average values of α, θ, φ, and V are used in these matrices.

B matrix (4 by 5 to 4 by 8): The B matrix is the starting estimate of the control matrix. The first four columns are for the control derivatives; the fifth column contains aerodynamic biases (treated as control derivatives, in which the control is defined as a constant value of 1 radian). Usually, only these five columns are required. If NCASE is greater than 1, independent aerodynamic biases may be determined for up to the first four maneuvers when necessitated by trim changes or other factors. In this event, the fifth column's aerodynamic biases are included in every maneuver, the sixth column's biases are included in all maneuvers after the first, the seventh column's biases are included in all maneuvers after the second, and the eighth column's biases are included in all maneuvers after the third. Thus the total aerodynamic bias on the first maneuver would be in column 5; for the bias on the second maneuver, columns 5 and 6 would be added; for the third maneuver, columns 5, 6, and 7 would be added; and for the fourth and all subsequent maneuvers, columns 5, 6, 7, and 8 would be added. For a lateral-directional case the B matrix should then be:

$$\begin{bmatrix} Y_{\delta_a} & Y_{\delta_r} & Y_{\delta_1} & Y_{\delta_2} & Y_0 & Y_{0_2} & Y_{0_3} & Y_{0_4} \\ L_{\delta_a} & L_{\delta_r} & L_{\delta_1} & L_{\delta_2} & L_0 & L_{0_2} & L_{0_3} & L_{0_4} \\ N_{\delta_a} & N_{\delta_r} & N_{\delta_1} & N_{\delta_2} & N_0 & N_{0_2} & N_{0_3} & N_{0_4} \\ 0. & 0. & 0. & 0. & \dot{\varphi}_0 & \dot{\varphi}_{0_2} & \dot{\varphi}_{0_3} & \dot{\varphi}_{0_4} \end{bmatrix}$$

For a longitudinal case the B matrix would be:

$$\begin{bmatrix} Z_{\delta_e} & Z_{\delta_c} & Z_{\delta_1} & Z_{\delta_2} & Z_0 & Z_{0_2} & Z_{0_3} & Z_{0_4} \\ M_{\delta_e} & M_{\delta_c} & M_{\delta_1} & M_{\delta_2} & M_0 & M_{0_2} & M_{0_3} & M_{0_4} \\ X_{\delta_e} & X_{\delta_c} & X_{\delta_1} & X_{\delta_2} & X_0 & X_{0_2} & X_{0_3} & X_{0_4} \\ 0. & 0. & 0. & 0. & \dot{\theta}_0 & \dot{\theta}_{0_2} & \dot{\theta}_{0_3} & \dot{\theta}_{0_4} \end{bmatrix}$$

AA array (4 by 4): The AA array defines which elements in the A matrix are to be determined by the program. Each element in the AA array should be either 1. or 0.. A 1. implies that the corresponding element in the A matrix will be estimated by the program, whereas a 0. implies that it will be held fixed at the starting value. If not read in, the AA array has the following default:

Longitudinal –

$$\begin{bmatrix} 1. & 0. & 0. & 0. \\ 1. & 1. & 0. & 0. \\ 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. \end{bmatrix}$$

Lateral-directional –

$$\begin{bmatrix} 1. & 1. & 0. & 0. \\ 1. & 1. & 1. & 0. \\ 1. & 1. & 1. & 0. \\ 0. & 0. & 0. & 0. \end{bmatrix}$$

BB array (4 by 5 to 4 by 8): The BB array defines which elements in the B matrix are to be determined in the same manner as the AA array defines those in the A matrix. If not read in, the BB array defaults to:

Longitudinal –

$$\begin{bmatrix} 1. & 0. & 0. & 0. & 1. \\ 1. & 0. & 0. & 0. & 1. \\ 0. & 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. & 1. \end{bmatrix}$$

Lateral-directional –

$$\begin{bmatrix} 1. & 1. & 0. & 0. & 1. \\ 1. & 1. & 0. & 0. & 1. \\ 1. & 1. & 0. & 0. & 1. \\ 0. & 0. & 0. & 0. & 1. \end{bmatrix}$$

AR matrix (4 by 4): The AR matrix is the *a priori* stability matrix and contains the *a priori* value of the A matrix. If the *a priori* feature is used, the estimates are weighted toward the AR matrix values. In general, the *a priori* values and the starting values are the same, but it is possible to distinguish between them. If not read in, the AR matrix is set equal to the A matrix.

BR matrix (4 by 5 to 4 by 8): The BR matrix is the *a priori* control matrix and plays a role similar to that of the AR matrix. If not read in, it is set equal to the B matrix.

APRA matrix (4 by 4): The APRA matrix contains *a priori* weightings for the stability matrix and contains the weightings to be assigned to the elements of the AR matrix for the *a priori* option. The program multiplies each relevant element in the APRA matrix by the overall weighting factor, WMAPR (NAMELIST item (52)), and assigns it an appropriate diagonal location in the D2 matrix (eq. (13)). No provision is made for the input of off-diagonal elements of the D2 matrix, although they are provided for in the algorithm. If not read in, the APRA matrix defaults to:

Longitudinal –

$$\begin{bmatrix} 13000. & 0. & 0. & 0. \\ 15. & 800. & 0. & 0. \\ 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. \end{bmatrix}$$

Lateral-directional –

$$\begin{bmatrix} 13000. & 13000. & 13000. & 0. \\ 0.15 & 500. & 5. & 0. \\ 15. & 800. & 800. & 0. \\ 0. & 0. & 0. & 0. \end{bmatrix}$$

APRB matrix (4 by 5 to 4 by 8): The APRB matrix contains *a priori* weightings for the control matrix and plays a role analogous to that of the APRA matrix. If not read in, the APRB matrix defaults to:

Longitudinal –

$$\begin{bmatrix} 13000. & 13000. & 13000. & 13000. & 0. & 0. & 0. & 0. \\ 15. & 15. & 15. & 15. & 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. \end{bmatrix}$$

Lateral-directional –

$$\begin{bmatrix} 13000. & 13000. & 13000. & 13000. & 0. & 0. & 0. & 0. \\ 0.15 & 0.15 & 0.15 & 0.15 & 0. & 0. & 0. & 0. \\ 15. & 15. & 15. & 15. & 0. & 0. & 0. & 0. \\ 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. \end{bmatrix}$$

AP array (3 by 4): The AP array is used in the formation of the observation matrix G of equation (2). For the aircraft identification problem, the observations generally available are either elements of the state vector, their derivatives, or accelerations. If only states and their derivatives are available, the G matrix would be identical to the A matrix. When accelerations are also of interest, the G matrix may still be expressed as a simple function of the A matrix; this function is specified by the AP array. For example, consider the two-degree-of-freedom longitudinal case:

$$\dot{\alpha} = Z_\alpha \alpha + q - \frac{g}{V} \cos(\varphi) \sin(\theta)\theta + Z_{\delta_e} \delta_e + \left(Z_0 + \frac{g}{V} \cos\varphi \cos\theta \right) \tag{25}$$

$$\left(a_n - a_{n_{bias}} \right) = -\frac{V}{g} Z_\alpha \alpha + 0q - 0\theta + \left(-\frac{V}{g}\right) Z_{\delta_e} \delta_e - \frac{V}{g}\left[Z_0 + \frac{g}{V} \cos\varphi \cos(\theta) \right] \tag{26}$$

where

$$a_{n_{bias}} = -\cos\varphi \cos\theta + a_{n_{instrument\ bias}}$$

From this example it can be seen that $\left(a_n - a_{n_{bias}}\right)$ can be computed like $\dot{\alpha}$ if appropriate terms are simply multiplied by constant values of $-\frac{V}{g}$ or 0. Thus each element in the G matrix can be defined as the product of the corresponding element in $R^{-1}A$ and a constant. These constants form the AP array. This formulation results in a considerable saving of computer time. It should be noted that the accelerometer offsets from the center of gravity (NAMELIST items (39) to (42)) add terms to the G matrix after the basic terms are computed from the AP array. If the AP array is read in, the BP array must also be read in. If not read in, the AP array defaults to the following standard forms:

Longitudinal —

$$\begin{bmatrix} -\frac{V}{g} & 0. & 0. & 0. \\ 1. & 1. & 1. & 1. \\ \frac{1}{g} & 0. & 0. & 0. \end{bmatrix}$$

Lateral-directional —

$$\begin{bmatrix} \frac{V}{g} & 0. & 0. & 0. \\ 1. & 1. & 1. & 1. \\ 1. & 1. & 1. & 1. \end{bmatrix}$$

BP array (3 by 5 to 3 by 8): The BP array plays a role analogous to that of the AP array. It defines the H matrix of equation (2) as a function of the B matrix. Each element in the H matrix is defined as the product of the corresponding elements in $R^{-1}B$ and the BP array. As in the G matrix, accelerometer offsets from the center of gravity may cause additional terms to be added to the basic H matrix. If either the AP or the BP array is read in, both must be read in. The BP array defaults to:

Longitudinal —

$$\begin{bmatrix} -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} & -\frac{V}{g} \\ 1. & 1. & 1. & 1. & 1. & 1. & 1. & 1. \\ \frac{1}{g} & \frac{1}{g} & \frac{1}{g} & \frac{1}{g} & \frac{1}{g} & \frac{1}{g} & \frac{1}{g} & \frac{1}{g} \end{bmatrix}$$

Lateral-directional –

$$\begin{bmatrix} \frac{V}{g} & \frac{V}{g} & \frac{V}{g} & \frac{V}{g} & \frac{V}{g} & \frac{V}{g} & \frac{V}{g} & \frac{V}{g} \\ 1. & 1. & 1. & 1. & 1. & 1. & 1. & 1. \\ 1. & 1. & 1. & 1. & 1. & 1. & 1. & 1. \end{bmatrix}$$

R matrix (4 by 4): The R matrix is an acceleration transformation matrix. If not read in, it defaults to the unit matrix for longitudinal cases, or for lateral-directional cases to:

$$\begin{bmatrix} 1. & 0. & 0. & 0. \\ 0. & 1. & -\frac{I_{XZ}}{I_X} & 0. \\ 0. & -\frac{I_{XZ}}{I_Z} & 1. & 0. \\ 0. & 0. & 0. & 1. \end{bmatrix}$$

D1 matrix (5 by 5 to 7 by 7): The D1 matrix is the signal weighting matrix. The diagonal elements are the weightings used for each response signal in the cost functional. The size of this matrix determines the number of signals used in the analysis; therefore, if $\dot{p}$ and $\dot{r}$ are not measured for a lateral-directional case, the D1 matrix should be 5 by 5. This reduction will save a significant amount of computer time. If the D1 matrix is diagonal, it should be entered as a vector containing the diagonal elements. The program will then recognize that the matrix is diagonal and take advantage of this in its computations. A vector is indicated by a header card with 0 for the number of columns. The vector is then entered on one card in an 8F10 format. If not read in, the D1 matrix is assumed to be diagonal with the following values:

Longitudinal –

$$\begin{bmatrix} 30000. & 200000. & 0. & 100000. & 2000. \end{bmatrix}$$

Lateral –

$$\begin{bmatrix} 500000. & 1500. & 1000000. & 30000. & 5000. \end{bmatrix}$$

ENDCASE.– The end of the matrix input is signaled by a card with ENDCASE starting in column 1. If no more cases follow, this card should have simply END instead of ENDCASE.

Card input.– If card input was specified, the input time histories are necessary here. For each time point there should be a record of two cards containing four time words (hours, minutes, seconds, milliseconds), seven observations, four controls, and four extra signals. The order of these quantities is given in NAMELIST item (11). The format is (3I2, I4, 7F10/8F10). Normally, the angular measurements are in degrees, the accelerations in g units, and the velocities in feet per second.

Data file input.— If tape input was specified, the time histories must be on an unformatted data file (either tape or disk). The device number of this file should be specified as 4 by the control cards. This file by default has 4 time words plus 15 data words per record, as in the card input. The length of the records on this file and the order of the parameters (except for the time words) may be changed by the use of the NREC and ORDER parameters (NAMELIST items (9) and (10)); alternately, the file may be specified to be in the special BOTH form (NAMELIST item (11)). Normally, the angular measurements are in degrees, the accelerations in g units, and the velocities in feet per second.

Output Description

Three basic forms of output are available from the MMLE program: printed, plotted (time history or derivative plots), and punched card.

Printed output.— The three levels of printed output are controlled by the parameters PRINT and TEST (NAMELIST items (19) and (20)). The basic output is always printed. If PRINT = T, measured and final computed time histories are also printed. If, in addition, TEST = T, time histories in radians, the transition matrices, and the first and second gradients of J are printed every iteration. The TEST parameter is generally used only for program debugging.

Appendix B presents a listing for a sample case with only the basic output. The first page (p. 112) of the output listing summarizes the input options chosen, and the second page lists the matrices read in. The dimensional and nondimensional starting values are then summarized. An asterisk indicates the values held fixed; the other values are to be determined as unknowns in the program. Each iteration includes a printout of the revised A and B matrices, the integral squared error on each input signal, the weighted errors on each signal, and the total error sum. This iterative loop may terminate in three ways. If the error sum exceeds ERRMAX (NAMELIST item (22)) at any time, the iteration will stop immediately and the input time history will be printed (not included in appendix B). If the maximum number of iterations is reached or the process converges within the range defined by BOUND (NAMELIST item (23)), normal termination will occur. The message "ITERATION TERMINATED, ERROR WITHIN .00100 BOUND" indicates that the convergence bound caused termination in the sample case.

Confidence levels in dimensional and nondimensional form are listed next. These confidence levels are analogous to the standard deviation. Their magnitude indicates the relative confidence to be placed in estimates of the same coefficient from different maneuvers. A small confidence level for a particular derivative estimate indicates that the estimate of the derivative should be very good. Confidence levels are useful in fairing estimated derivative values.

The final page (p. 117) of the first case is a summary of the converged values. The final dimensional and nondimensional derivatives are printed in the same format as the starting values, followed by the final A and B matrices. The final integral squared errors, weighted errors, and total error sum are printed, followed by a summary of the convergence of the error sum.

If either the D1 determination option (NAMELIST item (51)) or the *a priori* variation option (NAMELIST item (53)) is activated, the program prints an appropriate message at this point and begins its second pass through the estimation loop. The output resumes from the top of the third page. This output pattern would be repeated as many times as specified by the option. If more cases follow, the same output pattern is repeated for each case.

Plotted output.— If plotting is invoked (NAMELIST item (12)), time history plots like those in appendix B will be produced. On the observation signals, the solid lines represent the flight data and the dotted lines are the computed fits. When plotting is invoked and the *a priori* variation option (NAMELIST item (53)) is being used, time history plots are not produced, but, instead, the derivative plots discussed under that option (not included in appendix B).

Punched card output.— If PUNCH = T (NAMELIST item (24)), the nondimensional A and B matrices and confidence levels are punched on cards. These cards are preceded by a header card which contains the characters LATR or LONG followed by the first 35 characters of the title card and the values of MACH, ALPHA, PARAM, and CG. These cards are in the exact format required for the SUMARY plotting program. If the case is longitudinal, a computed $\delta_{e_{trim}}$ appears in the matrix location for C_{m_0}, and C_Z appears in the location for C_{Z_0}. These quantities are of more interest in this form, although the confidence levels are not readily available. (The confidence levels punched are those for the original C_{m_0} and C_{Z_0}.) The equations used to compute these parameters are:

$$\delta_{e_{trim}} = \frac{\left(C_m + C_{m_0}\right)}{C_{m_{\delta_e}}} \tag{27}$$

$$C_Z = C_{Z_0} + C_{Z_\alpha}\alpha + C_{Z_{\delta_e}}\delta_{e_{trim}} - \cos(\theta)\cos(\varphi)\frac{W}{\bar{q}S} \tag{28}$$

These equations are valid only for a two-degree-of-freedom case with no lateral-directional cross-coupling terms.

The final dimensional A and B matrices may be output on punched cards if PUNCHD = T (NAMELIST item (25)) is specified. These matrices may be used if it is desired to restart a case from the final values and run additional iterations. If the *a priori* feature is used in the restart, the original A and B matrices should be relabeled AR and BR and inserted (see discussion of AR and BR matrices, pp. 20-21) because the *a priori* values would be different from the new starting values. Any variable bias from the original run should also be subtracted from the data using FIXED (NAMELIST item (7)) in order to start at the same values as the final iteration of the previous run.

SETUP – PREPROCESSING PROGRAM

One of the most time-consuming portions of the analysis of aircraft stability and control derivatives is the preparation of input data for the derivative estimation program. The preprocessing program, SETUP, automates much of this work and is a key element in the routine processing of a large number of cases. It can produce, at the user's option, the data file and the punched input deck for the MMLE program. Listings of the program and its subroutines are presented in appendix C. A sample case is included in appendix D.

The SETUP program reads a set of predicted derivatives to be interpolated and dimensionalized for the given flight condition. The flight condition may be specified by the user, or if appropriate data were recorded on a flight tape, the program can obtain the flight condition automatically, given only the start and stop times for the case.

When the program is used in the most automated manner, the only inputs required for each case are the start and stop times, the type of case (longitudinal or lateral-directional), and an indication of which controls were used for the particular maneuver if more than one control is relevant. Using the program in this manner requires some preparation, but only at the beginning of the flight program rather than for each case. This distinction is important when several hundred cases are being analyzed, as has been done on several aircraft.

In preparation for the most automated use of the SETUP program, the user must write four small FORTRAN subroutines. Subroutine TAPEIN reads a flight data tape, finds the time interval requested, and places the data and times from the data into two arrays. The sample included in appendix D reads an unformatted tape with time in the first four words. Subroutine RDSET provides any initialization needed for TAPEIN; in the sample case it reads the number of channels on the input tape and the channel numbers of the data needed. Subroutine COND obtains the flight condition if it is to be computed automatically instead of read in manually. The averages of each of the data channels read in are available for use in this subroutine, and the subroutine can compute the required parameters from these averages. The sample obtains ALPHA, THETA, PHI, DETRIM, Q, V, and MACH from the data channel averages. The subroutine will also compute Q and V from knots indicated airspeed and altitude, if preferred. Weight, inertia, and center of gravity are not computed in the example subroutine, although they may be computed in user-supplied versions. Subroutine COND1 reads in any data needed in subroutine COND, for instance, tables of inertia versus fuel weight. This subroutine, as given in appendix C, is a null subroutine.

Input Description

The input data and the case specifications are described in the following sections.

Options.– The options to be used are specified by the following cards. All the options begin in column 1. The cards may appear in any order (except for the START card, as noted). Only the first four characters of each card are checked.

WRITE TAPE – instructs the program to write a data file for the MMLE program. This option automatically invokes the READ TAPE option.

PUNCH DECK – instructs the program to punch a data deck for the MMLE program.

READ TAPE – instructs the program to read an input tape. This option might be specified if input tape data are needed to determine the flight condition for the punched data card deck. This instruction is redundant if WRITE TAPE was specified.

START – signals the end of the options and the start of processing. This card must be the last card in the options section.

Vehicle characteristics.– The input segment that starts here and ends at, but does not include, *User-supplied data* (p. 30) is required if PUNCH DECK was specified in the preceding options. If PUNCH DECK was not specified, this segment must not be included.

NAMELIST/WIND/: The following parameters may be input in NAMELIST format:

(1) NABP – number of angle-of-attack breakpoints for predicted derivatives. Default value of 1 is used.

(2) NMBP – number of Mach number breakpoints for predicted derivatives. Default value of 1 is used.

(3) NBP – number of sets of predicted derivatives. Each set is identified subsequently as either lateral-directional or longitudinal and as having a particular value of the extra identifying parameter PARAM (used if the data are to be separated by some other criterion, such as wing sweep or flap position). Thus if there is one longitudinal and one lateral-directional data set and no additional distinction is made, NBP = 2. Dimensions in the program restrict the value of NBP to less than or equal to 8. Default value of 1 is used.

(4) LATR, LONG-(eight-word logical vectors) – parameters that specify dynamic modes of the predicted derivatives. The type of each set of predicted derivatives should be specified by setting the corresponding element of either LATR or LONG to true. Only one of the variables can be set to true in the NAMELIST. Default type for each set is longitudinal.

(5) NCLA, NCLO – number of coefficients per lateral-directional and longitudinal data set, respectively.

(6) CGLA, CGLO – reference center of gravity for lateral-directional and longitudinal predicted derivatives in fraction of reference chord. Default value of 0.25 is used.

(7) MZLA, MZLO – number of signals for the MMLE program to analyze in lateral-directional and longitudinal cases (that is, the length of the D1 vector; see D1 matrix description, p. 23). The values must be between 5 and 7, inclusive. Default value of 5 is used.

(8) WMLA, WMLO — overall *a priori* weighting for lateral-directional and longitudinal cases (WMAPR in MMLE program). If WMLA or WMLO are not entered, the SETUP program will not read the appropriate APRA and APRB matrices discussed subsequently and will use a weighting of 0. If WMLA or WMLO are set to 0, the corresponding APRA and APRB matrices will be read by the SETUP program and punched with the MMLE program card deck, although the weighting on the matrices will still be 0. If WMLA or WMLO is set to a positive value, the APRA and APRB matrices will be read and punched normally. If WMLA or WMLO is set to a negative value, the APRA and APRB matrices will not be read and the absolute value of WMLA or WMLO will be passed to the MMLE program (using the MMLE program's defaults for the APRA and APRB matrices). In all these cases, the lateral-directional usage and longitudinal usage are independent.

(9) DEG, RAD-(logical) — parameters that specify degrees or radians for units of predicted derivatives by setting either DEG = T or RAD = T. Only one of the two variables can be set to true in the NAMELIST. The rotary derivatives are per radian regardless of this option. Default condition is DEG = T.

(10) METRIC-(logical) — parameter that specifies SI (MKS) units if true and U.S. Customary (EGS) units if false. All input data units must be consistent with the system specified. Default condition is F.

(11) BODY, STAB-(logical) — parameters that specify axis system of longitudinal predicted derivatives as body or stability. Only one of the two variables can be set to true in the NAMELIST. (Lateral-directional data are in the body axes system independent of this option.) Default condition is STAB = T.

(12) S — value of reference wing area (ft^2 or m^2).

(13) SPAN — value of reference wing span (ft or m).

(14) CBAR — value of reference wing chord (ft or m).

(15) SPS — samples per second for data file. If not specified, 0 is passed to the MMLE program which then, by default, determines SPS from the times on the data file.

(16) PUNCH-(logical) — option passed to the MMLE program to control its PUNCH (MMLE NAMELIST item (24)) option to punch cards with final estimates of the nondimensional derivatives and confidence levels. Default condition is F.

(17) XB, XALF, ZB, XAY, ZAY, XAN, ZAX — instrument locations relative to the center of gravity. The meaning of each of these parameters is the same as that given in items (36) to (42) of the MMLE NAMELIST except that, as used here, these values refer to the reference center of gravity for the predicted derivatives instead of the flight center of gravity. If 0 is entered, it is assumed that the signals have been corrected to the flight center of gravity, and no additional correction terms will be used. Default value of 0 is used.

Vehicle name: The vehicle name is specified by up to eight characters, starting in column 1. These eight characters will be used on the title card punched out for the MMLE deck and will be included on the first line of the output from the SETUP program.

Lateral-directional weighting matrix: The lateral-directional D1 matrix is read in as a vector on one card in a 7F10 format. This vector is omitted if no lateral-directional predicted derivatives are read in. If every element is 0, the default in the MMLE program will be used.

Longitudinal weighting matrix: The longitudinal D1 matrix is read in as a vector. The comments for the lateral-directional D1 vector apply.

Lateral-directional APRA and APRB matrices: The APRA and APRB matrices for lateral-directional cases are in standard matrix input format. As mentioned above, these matrices are omitted if the WMLA parameter was not read in or was set to a negative value.

Longitudinal APRA and APRB matrices: The APRA and APRB matrices for longitudinal cases are in standard matrix format. The matrices are omitted if the WMLO parameter was not specified or was negative.

Predicted derivatives: NBP sets of predicted derivatives are required in the order specified in item (4) of SETUP NAMELIST/WIND/. Each set consists of data for NCLA or NCLO coefficients, depending on whether the set is lateral-directional or longitudinal. The data for each coefficient may be read as a function of Mach number and angle of attack, or as a function of Mach number only in the following forms.

The data for each coefficient begin with a header card containing the coefficient name in the first four columns and either a 1 or a 2 in column 10; a 1 indicates that the coefficient is a function of Mach number only, a 2 indicates that it is a function of Mach number and angle of attack. The only acceptable coefficient names are: lateral-directional – CYB, CLB, CNB, CLP, CNP, CLR, CNR, CYDA, CLDA, CNDA, CYDR, CLDR, CNDR, CYD1, CLD1, CND1, CYD2, CLD2, CND2; longitudinal (body axes) – CNA, CMA, CAA, CMQ, CNV, CMV, CAV, CNDE, CMDE, CADE, CNDC, CMDC, CADC, CND1, CMD1, CAD1, CND2, CMD2, CAD2, CN, CA; longitudinal (stability axes) – CLA, CMA, CDA, CMQ, CLV, CMV, CDV, CLDE, CMDE, CDDE, CLDC, CMDC, CDDC, CLD1, CMD1, CDD1, CLD2, CMD2, CDD2, CL, CD. The first two characters of each name indicate the force or moment coefficients (for lateral-directional, CY = side force, CL = rolling moment, and CN = yawing moment; for longitudinal, CL = lift force, CD = drag force, CN = normal force, CA = longitudinal force (positive direction is rearward)), and the remaining characters indicate the quantity with respect to which the derivative is taken. (A ~ angle of attack, B ~ angle of sideslip, P, Q, R ~ angular rates, V ~ velocity, DE, DC, DA, DR, D1, and D2 ~ controls.)

If the coefficient is a function of Mach number and angle of attack, the data for each Mach number appear on a separate card, with each card containing the values of the coefficient for the NABP angle-of-attack breakpoints. These cards are in an 8F10 format, and the card entries may be continued on additional cards if needed.

If the coefficient is a function of Mach number only, the values for the NMBP Mach number breakpoints appear on one card in an 8F10 format. As before, this card may be continued if needed.

Angle-of-attack breakpoints: A card containing the NABP values of the angle-of-attack breakpoints in an 8F10 format is necessary. If NABP = 1, this card may be blank.

Mach number breakpoints: A card containing the NMBP values of the Mach number breakpoints in an 8F10 format is necessary. If NMBP = 1, this card may be blank.

Arbitrary parameter breakpoints: A card containing the NBP values of PARAM to distinguish the predicted derivative data sets is necessary. If no distinction other than longitudinal and lateral-directional is used, this card may be blank. The card is in an 8F10 format.

User-supplied data for subroutine COND1.— Any input required for subroutine COND1 goes in the input data at this point. With the subroutine supplied, there is none.

Input tape data.— The input tape data section should be omitted if the READ TAPE option is not active. Any input required by subroutine RDSET is made here. The subroutine supplied requires a card with the number of data words per record of the input tape; this card is in an I5 format. This is followed by three cards containing the channel numbers of the 40 channels to be used; each of these cards is in a 16I5 format. A 0 indicates a signal not used. The first 25 signals will be put on the MMLE program tape if a tape is written. (The signals should be in the BOTH order defined by item (11) in the MMLE NAMELIST.) The last 15 of the 40 channels are reserved for use in subroutine COND, should they be needed. These last 15 channels are typically used for fuel weight, flap position, or any other quantities useful in identifying the flight condition and vehicle configuration. The SETUP program automatically averages the values of all 40 data channels over the requested time interval and passes these averages to subroutine COND through a labeled common block.

Case specification.— The case specification is repeated as many times as necessary, once for each case to be analyzed.

Time card: The start time and end time for the case in hours, minutes, seconds, and milliseconds are required. The format is 2(3I2,I3,1X).

NAMELIST/COND/: The following parameters may be read in NAMELIST/COND/:

(1) LONG, LATR-(logical) – type of case to be analyzed. Set either LONG or LATR to true. Only one of the two variables can be set to true in the NAMELIST.

(2) CASE-(integer) – case number. Default value of 0 is used.

(3) DELTA-(four-word logical vector) — option that specifies which controls were used in the maneuver. A value of T for any element of DELTA indicates that the corresponding control was used. If all four locations are F (default condition), the MMLE program default is used; this default is δ_e for longitudinal cases, δ_a and δ_r for lateral-directional cases. If DELTA is omitted in a case but has been specified in a previous case of the same type (longitudinal or lateral-directional), it will assume the values of the previous case.

(4) FLT-(integer) — flight number. This identification is needed only on the first case.

All the following items may be set in subroutine COND instead of reading them in at this point. The subroutine supplied will set ALPHA, THETA, PHI, DETRIM, Q, V, and MACH if the READ TAPE option is active.

(5) ALPHA — average angle of attack.

(6) THETA — average pitch attitude. Default value of 0 is used.

(7) PHI — average roll attitude. Default value of 0 is used.

(8) Q — average dynamic pressure.

(9) V — average velocity.

(10) MACH-(real) — average Mach number.

(11) PARAM — extra identifying parameter. If nonzero, the predicted derivative data with the same value of PARAM will be used for the derivatives. If there is only one longitudinal data set or one lateral-directional data set, or a longitudinal and a lateral-directional data set, PARAM need not be specified. Default value of 0 is used.

(12) W — aircraft weight (pounds or newtons).

(13) IX, IY, IZ-(real) — moments of inertia (slug-ft^2 or kg-m^2).

(14) IXZ-(real) — cross-product of inertia (slug-ft^2 or kg-m^2). Default value of 0 is used.

(15) CG — center of gravity in fraction of chord. Default is the predicted derivative reference value.

(16) DETRIM — trimmed value of δ_e. Default value of 0 is used.

Items (17) and (18) are simply for convenience if $\bar{q}$ and V are not readily available. The subroutine COND supplied may compute $\bar{q}$ and V from the values of indicated airspeed and altitude, using an approximation to the standard atmosphere.

(17) KIAS-(real) — knots indicated airspeed. If KIAS is nonzero, $\bar{q}$ and V will be computed. Default value of 0 is used.

(18) ALT — altitude (ft or m). Default value of 0 is used.

End card: The last card in the data deck contains a -1 in the first two columns to indicate the end of the data.

Output Description

The two primary outputs of the SETUP program are the MMLE program data tape and the punched card deck. These outputs are described in the MMLE Input Description section. A permanent disk file may be substituted for the data tape, without modifying the program. The punched card deck from SETUP will be ready to run through the MMLE program with the addition of control cards and the substitution of an END card for the last ENDCASE card at the end of the deck.

The printed output includes the predicted derivatives. For each case the data channel averages as passed to subroutine COND are printed if an input tape was read. All matrices punched in the MMLE program card deck are also printed for easy reference. A sample case is presented in appendix D.

SUMARY — PLOTTING PROGRAM

Data presentation can be a time-consuming portion of the derivative estimation process when a large number of maneuvers are involved. It is still common to laboriously plot derivatives and wind-tunnel data by hand, a procedure which can easily take longer than the entire estimation process. To efficiently utilize available manpower, graphs or data listings should be automatically produced. The SUMARY program produces plots of estimated derivatives and confidence levels as a function of angle of attack and, if desired, provides predicted derivative values for comparison. The program is presented as a prepared package that may be modified to meet users' specific data presentation requirements. Listings of the program and its subroutines are presented in appendix E. A sample case is given in appendix F.

The SUMARY program reads a set of predicted and flight-determined derivatives, and plots specific groups of the data as instructed. Several groups may appear on one plot, indicated by different symbols. The same predicted derivative card deck used for the SETUP program may be used in the SUMARY program, or predicted derivatives may be omitted. The flight-determined derivatives are punched out by the MMLE program in the exact format required for the SUMARY program.

Input Description

Title card.— The title card contains any information needed to identify a particular set of data that is appropriate to include in the printed output. All 80 columns on this card may be used.

NAMELIST/WIND/.— Parameters in NAMELIST/WIND/ are as follows:

(1) NABP — number of angle-of-attack breakpoints for predicted derivatives. Default value of 1 is used.

(2) NMBP — number of Mach number breakpoints for predicted derivatives. Default value of 1 is used.

(3) NBP — number of sets of predicted derivatives. The definition of a set of predicted derivatives is the same as that in the SETUP program. Default value of 1 is used.

(4) LONG, LATR-(eight-word logical vectors) — types of each set of predicted derivatives. The type is specified by setting corresponding element of either LONG or LATR to true. Only one of the two variables can be set to true in the NAMELIST. Default type for each set is longitudinal.

(5) NCLA, NCLO — number of coefficients in lateral-directional and longitudinal data sets, respectively. Default value of 0 is used.

(6) CGLA, CGLO — reference centers of gravity for lateral-directional and longitudinal predicted derivatives in fraction of chord. Default value of 0.25 is used.

(7) SHIFT-(logical) — parameter that corrects data for center-of-gravity location. If true, the flight C_{m_α} and C_{n_β} will be corrected to the predicted derivative reference center of gravity. Default condition is F.

(8) DEG, RAD-(logical) — options that specify degrees or radians for units of predicted derivatives. Only one of the two variables can be set to true in the NAMELIST. Rotary derivatives are per radian regardless of this option. Default units are degrees.

(9) BODY, STAB-(logical) — options that specify body or stability axes for input of predicted derivatives. If STAB = T, longitudinal predicted derivatives are converted from stability to body axes. If BODY = T, no conversion is made. Only one of the two variables can be set to true in the NAMELIST. Default condition is STAB = T.

(10) PRINT-(logical) — option that prints out predicted derivatives, if true. Default condition is F.

(11) WTPLOT-(logical) — option that plots predicted derivatives, if true. Default condition is T.

(12) CBAR, SPAN — aircraft reference chord and span, respectively. These quantities are needed only if SHIFT = T and there are lateral-directional data. Default values of CBAR = 0 and SPAN = 10^{50} are used.

(13) AMIN, AMAX — minimum and maximum for values on angle-of-attack axis. Default values of AMIN = 0 and AMAX = 12. are used.

(14) ASCALE — scale for angle-of-attack axis in degrees per centimeter. Default value of 1. is used.

(15) YLEN — length of ordinate axis in centimeters. Default value of 10. is used.

(16) XDIST — X-distance between plots in centimeters. Default value of 10. is used.

(17) CRFACT — factor by which confidence levels are multiplied before plotting. If equal to 0, no confidence levels are plotted. Default value of 1. is used.

(18) NPARAM — variable which distinguishes the two modes of data organization to be used. If NPARAM = 0, flight data points are sorted by Mach number to the nearest Mach number breakpoint. Plots are then produced with the different Mach numbers indicated by different symbols. If NPARAM > 0, Mach number is ignored and the data are sorted by the value of PARAM, the extra identifying parameter, to the nearest PARAM breakpoint. Plots are then produced with different symbols distinguishing these groups. The lowest Mach number of the predicted derivatives is plotted if more than one Mach number breakpoint is specified. Only one predicted derivative curve is plotted. In this case there should be only one set of lateral-directional and one set of longitudinal predicted derivatives; if there is more than one set, only the first will be plotted. Default value of 0 is used.

Predicted derivatives.— The NBP sets of predicted derivatives are necessary in exactly the same format required for the SETUP program, including the cards with angle of attack, Mach number, and PARAM breakpoints.

Flight data.— The flight data desired are required at this point in the form punched on cards by the MMLE program if PUNCH = T (p. 25).

(1) Header card — TYPE, TITLE, MACH, ALPHA, PARAM, CG in format A4,1X,A35,4F10. TYPE is either LONG or LATR.

(2) A, B, AC, BC matrices in nondimensional form. The AC and BC matrices contain the confidence levels. The fifth column of the B matrix in a longitudinal case should contain C_Z in the first row and $\delta_{e_{trim}}$ in the second row if they are desired for plotting. These quantities replace the logically expected, but more difficult to interpret, quantities (perturbation C_{Z_0} and C_{m_0}) from which they are derived.

Plotting instructions.— The end of the flight data and the beginning of the plotting instructions are signaled by a card with PLOT in the first four columns. Then, for each set of plots desired, the following instruction cards are needed:

(1) TYPE, PARM, TOL — TYPE is either LATR or LONG. PARM should equal one of the PARAM breakpoints of the predicted derivatives. The program will then select the corresponding set of predicted derivatives to be used. Flight data points with this same value of PARAM (±TOL) will be selected for plotting. For instance, if PARM = 35. and TOL = 2., a flight point with PARAM = 36. will be plotted, but

a flight point with PARAM = 38. will be rejected. In the special case, PARM = 0, the first set of predicted derivatives of the correct type (LATR, LONG) is used together with all the flight data. The format of this card is A4,F6,F10.

(2) Up to six cards specifying the derivatives to be plotted and the scales to use. Four plot instructions are included on a card (less may be on the last card). Each plot instruction is of the form DERIV, SMIN, SMAX; DERIV is the derivative name, and SMIN and SMAX are the minimum and maximum values for the ordinate. The valid derivative names are the same as those in the SETUP program for lateral-directional data; for longitudinal data, all the body axis derivative names except CA are valid and the additional name of DE may be used to plot $\delta_{e_{trim}}$ versus α_{trim}. If SMIN = SMAX (in particular, if left blank), automatic scaling will be used for the plot. The format of these cards is 4(A4,F6,F10).

End card.— The end of the plotting instructions is signaled by a card with END starting in column 1.

Output Description

The printed output from the SUMARY program includes the header cards for all flight points read in and a summary of the plotting instructions. The predicted derivatives are printed if PRINT is set to T. In addition, informative messages are provided if no predicted derivatives or flight data are available at a requested condition.

Plots are scaled for centimeter grid paper. Confidence levels are indicated by vertical bars. Predicted derivative data are identified by small symbols that correspond to those in the figure legend, at the beginning and end of each curve. A sample is shown in appendix F.

CONCLUDING REMARKS

A digital computer program written in FORTRAN IV has been successfully applied by relatively inexperienced personnel to aircraft linear parameter estimation problems with measurement noise but no state noise. This maximum likelihood estimation program includes an option for using *a priori* information and provides estimates of the derivatives and confidence levels. A program to automate the setup work and a program to plot the results have also been written. The three programs form a package which has been used to successfully analyze 1500 maneuvers on 20 aircraft.

Flight Research Center
National Aeronautics and Space Administration
Edwards, Calif., January 22, 1975

APPENDIX A

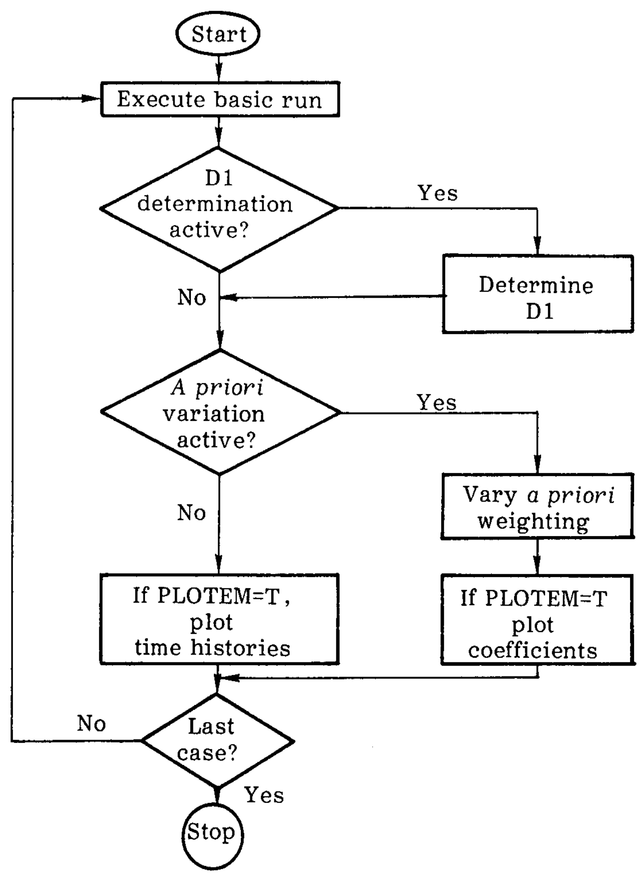
MMLE PROGRAM AND SUBROUTINES

Listings of the main program and the subroutines used in the MMLE program are presented. The listings are preceded by a brief description, a flow chart, when needed for clarification, and programing notes which explain some of the conventions used and point out items needed to understand the operation of the program.

MAIN MMLE PROGRAM

Description: The main MMLE program activates the three operating modes of the program (basic mode, D1 determination mode, and *a priori* variation mode).

Flow chart:



Programing notes: The PROGRAM card is required on CDC 6000/7000 systems. On an IBM 360/370 system the following DD cards, or equivalent information, are necessary to perform the same function as the PROGRAM card:

```
//GO.FT02F001 DD SYSOUT=B,SPACE=(TRK,10,RLSE),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=3520)
//GO.FT03F001 DD SYSOUT=A,SPACE=(TRK,50,RLSE),
// DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3458)
//GO.FT04F001 DD DUMMY
```

(Substitute the appropriate DD card for the input file if a tape or disk input is used.)

```
//GO.FT08F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(CYL,(10,2)),
// DCB=(RECFM=VSB,LRECL=92,BLKSIZE=924),DSN='PLOTTER DATA'
//GO.FT07F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(CYL,(10,2)),
// DCB=(RECFM=VSB,LRECL=84,BLKSIZE=844),DSN='INTERNAL'
//GO.PLOTTAPE DD DUMMY
```

(Substitute the appropriate DD card for the plotter file as used on the particular system. The file name will be either PLOTTAPE or FT13F001, depending on the plotter software used.)

```
//GO.FT01F001 DD*
```

This routine alters PRINT and PLOTEM to suppress any extraneous output during intermediate steps of the D1 determination and the *a priori* variation option.

Important variables –

ND1, NAPR – control the D1 determination and *a priori* variation options as described in MMLE NAMELIST input.

D2 – vector of final weighted relative errors returned from the estimation process.

STORE – storage for final coefficient values during *a priori* variation. It is used to plot these values.

Program listing:

```
      PROGRAM MMLE(INPUT,PUNCH,OUTPUT,TAPE4,TAPE7,TAPE8,TAPE13,
     -     TAPE1=INPUT,TAPE2=PUNCH,TAPE3=OUTPUT)
C
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /BUF/ BUFFER,YO,THGT
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,RI
      COMMON /COM/ NCASE,MZ,NPTS,NPT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -     D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      DIMENSION NPTS(15),D1(8,7),AHOLD(5,4),
     -     BHOLD(5,8),D2(7),A(5,4),B(5,8),AP(4,4),BP(4,8),STORE(14,27)
     -     ,BUFFER(1024),RI(5,4)
      LOGICAL PLOTEM,LONG,LATR,PLT,AA(5,4),BB(5,8),STP,PRINT,PRNT,
     -     FIRST,LAST
      FIRST=.TRUE.
      LAST=.FALSE.
    5 REWIND 4
      REWIND 8
      REWIND 7
      CALL EDIT
      IF(ND1.EQ.0.AND.NAPR.LT.1) GO TO 10
      PLT=PLOTEM
      IF(NAPR.GT.0) PLOTEM=.FALSE.
      PRNT=PRINT
      WHOLD=WMAPR
      WMAPR=0.
      MAX=5
      CALL AMAKE(AHOLD,A)
      CALL AMAKE(BHOLD,B)
C**************************************** BASE RUN
   10 CALL DATA(.TRUE.)
      CALL AGIRL
      IF(ND1.EQ.0) GO TO 15
      PLOTEM=.FALSE.
      PRINT=.FALSE.
   15 CALL OUTPUT(D2)
      IF (ND1.EQ.0) GO TO 100
C**************************************** D1 DETERMINATION (IF DESIRED)
      TOLI=1./D1TOL
      DO 90 I=1,ND1
      STP=.TRUE.
      DO 30 J=1,MZ
      IF(D1    (J,J).NE.0.) GO TO 22
      D2(J)=1.
      GO TO 30
   22 IF(D2(J).GT.D1TOL.OR.D2(J).LT.TOLI) STP=.FALSE.
      IF(D2(J).GT.1.) GO TO 25
      D2(J)=(1./D2(J)-1.)*D1RLX+1.
      GO TO 27
   25 D2(J)=1./((D2(J)-1.)*D1RLX+1.)
   27 D1    (J,J)=D1    (J,J)*D2(J)
      D2(J)=SQRT(D2(J))
   30 CONTINUE
      IF(I.LT.ND1.AND..NOT.STP) GO TO 40
      PLOTEM=PLT
      PRINT=PRNT
   40 WRITE(3,2000)
```

```
      MAX=8
      CALL ASPIT(D1)
      MAX=5
      CALL AMAKE(A,AHOLD)
      CALL AMAKE(B,BHOLD)
      CALL DATA(.FALSE.)
      CALL AGIRL
      CALL OUTPUT(D2)
      IF(STP) GO TO 95
   90 CONTINUE
   95 WRITE(3,2002)
      MAX=8
      CALL ASPIT(D1)
  100 IF(NAPR.GT.0) GO TO 105
      IF(.NOT.PLOTEM) GO TO 200
      CALL THPLOT(FIRST)
      FIRST=.FALSE.
      GO TO 200
C************************************** APRIORI VARIATION (IF DESIRED)
  105 PRINT=.FALSE.
      IF(WHOLD.EQ.0.) WHOLD=.001
      WMAPR=WHOLD
      I=0
  110 I=I+1
      JKMM=0
      DO 130 J=1,3
      DO 120 K=1,4
      IF(BB(J,K)) GO TO 120
      JKMM=JKMM+1
      STORE(I,JKMM)=B(J,K)
  120 CONTINUE
      DO 130 K=1,3
      IF(AA(J,K)) GO TO 130
      JKMM=JKMM+1
      STORE(I,JKMM)=A(J,K)
  130 CONTINUE
      STORE(I,JKMM+1)=ERRSUM
      MAX=5
      CALL AMAKE(A,AHOLD)
      CALL AMAKE(B,BHOLD)
      IF(I-NAPR) 140,110,160
  140 WRITE(3,2001)WMAPR
      CALL DATA(.FALSE.)
      CALL AGIRL
      CALL OUTPUT(D2)
      WMAPR=WMAPR*WFAC
      GO TO 110
  160 IF(.NOT.PLT) GO TO 200
      CALL APRPLT(STORE,AA,BB,NAPR,WHOLD,WFAC,LONG,FIRST,LAST,RATIO)
      FIRST=.FALSE.
  200 IF(.NOT.LAST) GO TO 5
      IF(.NOT.FIRST) CALL PLOT(0.,0.,999)
 2000 FORMAT(15H0D1 REVISED TO:)
 2001 FORMAT(12H0WMAPR NOW =,E10.2)
 2002 FORMAT(10H0FINAL D1:)
      STOP
      END
```

SUBROUTINE EDIT

Description: Subroutine EDIT initializes the program, sets defaults, and reads input options and matrices.

Programing notes: If used with a system that does not support the NAMELIST, some other form of input might be used.

Subroutine MATLD, called at card 1820, sets appropriate elements of ABC to -99999 when reading a matrix. These elements are then tested after all the matrix input has been made to determine what matrix defaults are needed.

The R matrix is inverted at card 2460, since R^{-1} is the form needed by the rest of the program.

From card 2530 on, the AA and BB matrices are being converted to logical variables and the number of the different types of unknown coefficients to be determined is found. An element in AA or BB is set to false if that element in A or B is to be determined. This may be contrary to the expected convention.

Subroutine listing:

```
      SUBROUTINE EDIT
C
C     SETS DEFAULT VALUES AND READS PROGRAM OPTIONS FROM CARDS
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /TOPLOT/ ZMAX,ZMIN,DCMAX,DCMIN,TIMESC,NCPLOT
      COMMON /TOGIRL/JKM,JKMM,JKMM1,ERRMAX,ZEROIN,XT5,BOUND,APR,NI
     -      ,VAR,ZERO,APRD,JKV,DIAG
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,R
      COMMON /COM/ NCASE,MZ,NPTS,NPTT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -      D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      COMMON /INFO/ HH,NOITER,MX,MXP1,MU,TEST,XBN,ZBX,IPQR,IXYZ,XT3,MZM,
     -  CORECT,BIASKN,PLTMAX,XT4,ERRVEC,PUNCHD,NEAT
      COMMON /HEADNG/ LABELS,TITLE,JULIAN
      COMMON /TODATA/ S,SPAN,XB,ZB,XAY,CARD,ZAY,APRA,APRB,DC,
     -      XALF,THIN,TAPE,CBAR,APBP,STC,ETC,FIXED,AR,BR,XAN,ZAX,
     -      SCALE,NREC,ORDER,METRIC,IX,IY,IZ,IXZ,Q,V,GROSWT
      COMMON /ROUTH/ PUNCH ,PARAM,MACH,ALPHA,CG,AC,BC
      INTEGER STC(15),ETC(15),THIN,ST(4),ET(4),
     -      LABELS(15),LONLAB(15),LATLAB(15),ORDER(15)
      LOGICAL CARD,TAPE,CORECT,METRIC,APBP,PUNCH,ZEROIN,PUNCHD,
     -          LAA(5,4),LBB(5,8),LONG,LATR,VAR(3),ZERO(4),LAST,
     -      BIASKN,PLOTEM,TEST,PRINT,BOTH,DIAG,INCH
      REAL IX,IY,IZ,IXZ,MACH,MATRX(8,8),JULIAN,AC(5,4),BC(5,8),LAB(12)
      DIMENSION A(5,4),B(5,8),TITLE(20),DCMAX(8),DCMIN(8),XT4(3),
     -      AA(5,4),BB(5,8),AP(4,4),BP(4,8),NPTS(15),D1(8,7),APRD(35),
     -                  ZMIN(7)   ,ZMAX(7)   ,ERRVEC(20),DC(4),APR(35,35),
     -      XT5(35),AR(5,4),BR(5,8),APRA(5,4),APRB(5,8),ABC(12),FIXED(7),
     -      APRLON(5,4),APRLAT(5,4),BPRLON(5,8),BPRLAT(5,8),TLAT(3),
     -      TLON(3),TYPE(3),SCALE(7),R(5,4),XT3(4),AALAT(5,4),AALON(5,4),
     -      BBLAT(5,8),BBLON(5,8),D1LON(5),D1LAT(5)
      EQUIVALENCE (AA(1,1),LAA(1,1)),(BB(1,1),LBB(1,1))
      DATA LONLAB/4HALFA,1HQ,1HV,4HTHET,2HAN,4HQDOT,2HAX,2HDE,2HDC,
     -      3HDC1 ,3HDC2 ,3HPHI,3HALT,4HMACH,4HQBAR/,LATLAB/4HBETA,1HP,
     -      1HR,3HPHI,2HAY,4HPDOT,4HRDOT,2HDA,2HDR,3HDC1,3HDC2,4HALFA
     -      ,1HV,4HMACH,4HQBAR/,LAB/1HA,1HB,2HAA,2HBB,2HAR,2HBR,4HAPRA,
     -      4HAPRB,2HD1,2HAP,2HBP,1HR/,SUML/3HSUM/,TLAT/4HLATE,3HRAL,
     -      1H /,TLON/4HLONG,4HITUD,4HINAL/,AALAT/3*1.,0.,4.,3*1.,0.,4.,
     -      0.,1.,1.,7*0./,BBLAT/3*1.,0.,4.,3*1.,0.,8.,10*0.,4*1.,16*0./,
     -      AALON/1.,1.,0.,0.,4.,0.,1.,0.,0.,4.,10*0./,BBLON/1.,1.,0.,0.,
     -      4.,4*0.,8.,10*0.,1.,1.,0.,1.,16*0./,D1LON/30000.,200000.,0.,
     -      100000.,2000./, APRLON/13000.,15.,2*0.,4.,0.,800.,2*0.,4.,
     -      10*0./,APRLAT/13000.,.15,15.,0.,4.,13000.,500.,800.,0.,4.,
     -      13000.,5.,800.,7*0./,BPRLAT/13000.,.15,15.,0.,4.,13000.,.15,
     -      15.,0.,8.,13000.,.15,15.,2*0.,13000.,.15,15.,22*0./,
     -      BPRLON/13000.,15.,2*0.,4.,13000.,15.,2*0.,8.,13000.,15.,3*0.,
     -      13000.,15.,23*0./,D1LAT/500000.,1500.,1000000.,30000.,5000./
      NAMELIST /INPUT/  GROSWT,Q,S,SPAN,CBAR,V,IX,IY,IZ,IXZ,PUNCHD,
     -                XB,ZB,XAY,ZAY,XALF,XAN,ZAX,WMAPR,PLTMAX,NEAT,
     -      CG,MACH,ALPHA,PARAM,SPS,NCASE,NOITER,TEST,PLOTEM,TIMESC,
     -      PUNCH,THIN,LONG,LATR,WFAC,ND1,CARD,TAPE,BOUND,ERRMAX,
     -      METRIC,PRINT,NAPR,D1RLX,D1TOL,FIXED,VAR,DC,INCH,
     -      ZERO,SCALE,ZMIN,ZMAX,DCMIN,DCMAX,NREC,ORDER,BOTH,NCPLOT
      JULIAN=DATE(JULIAN)
      APR(35,3)=SUML
      READ (1,2000) TITLE
      WRITE(3,2005)TITLE,JULIAN
```

```
C************************************** DEFAULTS                         EDIT 570
      NCPLOT=8                                                          EDIT 580
      V=0.                                                              EDIT 590
      Q=0.                                                              EDIT 600
      MACH=0.                                                           EDIT 610
      PUNCHD=.FALSE.                                                    EDIT 620
      NEAT=0                                                            EDIT 630
      NREC=15                                                           EDIT 640
      METRIC=.FALSE.                                                    EDIT 650
      BOTH=.FALSE.                                                      EDIT 660
      DO 14 I=1,15                                                      EDIT 670
   14 ORDER(I)=I                                                        EDIT 680
      DO 10 I=1,8                                                       EDIT 690
      DCMIN(I)=0.                                                       EDIT 700
   10 DCMAX(I)=0.                                                       EDIT 710
      DO 13 I=1,12                                                      EDIT 720
   13 ABC(I)=LAB(I)                                                     EDIT 730
      CORECT=.FALSE.                                                    EDIT 740
      CARD=.FALSE.                                                      EDIT 750
      TAPE=.TRUE.                                                       EDIT 760
      ZEROIN=.FALSE.                                                    EDIT 770
      BIASKN=.FALSE.                                                    EDIT 780
      PLOTEM=.TRUE.                                                     EDIT 790
      TEST=.FALSE.                                                      EDIT 800
      LONG=.FALSE.                                                      EDIT 810
      LATR=.FALSE.                                                      EDIT 820
      DIAG=.TRUE.                                                       EDIT 830
      PLTMAX=1.E+05                                                     EDIT 840
      ERRMAX=1.E+20                                                     EDIT 850
      PUNCH=.FALSE.                                                     EDIT 860
      PARAM = 0.                                                        EDIT 870
      CG = .25                                                          EDIT 880
      XB=0.                                                             EDIT 890
      ZB=0.                                                             EDIT 900
      XAY=0.                                                            EDIT 910
      ZAY=0.                                                            EDIT 920
      THIN=1                                                            EDIT 930
      D1(8,1)=5.                                                        EDIT 940
      D1(8,2)=5.                                                        EDIT 950
      MAX=8                                                             EDIT 960
      CALL AZOT(D1)                                                     EDIT 970
      MAX=5                                                             EDIT 980
      MIX=5                                                             EDIT 990
      R(5,1)=4.                                                         EDIT1000
      R(5,2)=4.                                                         EDIT1010
      R(5,3)=ABC(12)                                                    EDIT1020
      CALL AZOT(R)                                                      EDIT1030
      DO 136 I=1,4                                                      EDIT1040
      R(I,I)=1.                                                         EDIT1050
      ZERO(I)=.FALSE.                                                   EDIT1060
  136 DC(I) = 0.                                                        EDIT1070
      XALF=0.                                                           EDIT1080
      ALPHA=999.                                                        EDIT1090
      PRINT=.FALSE.                                                     EDIT1100
      DO 137 I=1,7                                                      EDIT1110
      ZMIN(I)=0.                                                        EDIT1120
      ZMAX(I)=0.                                                        EDIT1130
```

```
      FIXED(I)=0.
  137 SCALE(I)=1.
      XAN=0.
      ZAX=0.
      BOUND=.001
      SPS=0.
      WMAPR=0.
      NOITER=6
      NCASE=1
      NI=35
      TIMESC=1.
      DO 11 I=1,3
      VAR(I)=.TRUE.
   11 TYPE(I)=TLAT(I)
      S=.001
      SPAN=.001
      CBAR=.001
      GROSWT=1.E+09
      IY=1.E+09
      IX=1.E+09
      IZ=1.E+09
      IXZ=0.
      ND1=0
      NAPR=0
      WFAC=100.
      D1RLX=1.2
      D1TOL=1.4
      INCH=.FALSE.
      RATIO=.7874
C************************************** READ PROGRAM OPTIONS
      READ (1,INPUT)
      IF(INCH) RATIO=1.
      IF(NOITER.EQ.0) PUNCH=.FALSE.
      IF(NOITER.EQ.0) PUNCHD=.FALSE.
      PLTMAX=AMIN1(PLTMAX,ERRMAX)
      IF(CARD) TAPE=.FALSE.
      ATHIN=THIN
      IF(SPS.NE.0.) HH=ATHIN/SPS
      IF(BOTH) NREC=25
      IF (LONG) GO TO 5
      DO 2 I=1,15
    2 LABELS(I)=LATLAB(I)
      GO TO 8
    5 DO 6 I=1,15
    6 LABELS(I)=LONLAB(I)
      DO 12 I=1,3
   12 TYPE(I)=TLON(I)
    8 CONTINUE
      ZEROIN = ZERO(1).OR.ZERO(2).OR.ZERO(3).OR.ZERO(4)
      BIASKN = VAR(1).OR.VAR(2).OR.VAR(3)
      WRITE(3,2009)TYPE,CARD,TAPE,SPS,THIN,NREC,BOTH
      WRITE(3,2010)WMAPR,NEAT,NOITER,BOUND,ERRMAX
      IF(ND1.NE.0) WRITE(3,2006)ND1,D1RLX,D1TOL
      IF(NAPR.NE.0) WRITE(3,2008)NAPR,WMAPR,WFAC
      WRITE(3,2011)PLOTEM,PLTMAX,NCPLOT,TIMESC,PRINT,TEST,PUNCH,PUNCHD
      WRITE(3,2012)METRIC,Q,V,MACH,ALPHA,CG,PARAM,S,SPAN,CBAR,IX,IY,IZ,
     1     IXZ,GROSWT,XALF,XAN,XB,XAY,ZB,ZAY
```

```
      WRITE(3,2013)LABELS,VAR,ZERO,FIXED,DC,SCALE                          EDIT1710
      IF(PLOTEM) WRITE(3,2001)ZMIN,DCMIN,ZMAX,DCMAX                        EDIT1720
      SPS=SPS/ATHIN                                                        EDIT1730
      DO 100 I=1,NCASE                                                     EDIT1740
      READ (1,1000) ST,ET                                                  EDIT1750
      STC(I)=ST(4)+1000*(ST(3)+60*ST(2)+3600*ST(1))                        EDIT1760
      ETC(I)=ET(4)+1000*(ET(3)+60*ET(2)+3600*ET(1))                        EDIT1770
  100 WRITE(3,2002)I,ST,ET                                                 EDIT1780
C*************************************** READ MATRICES                     EDIT1790
      WRITE(3,2003)     TITLE,JULIAN                                       EDIT1800
      WRITE(3,2004)                                                        EDIT1810
      MAX=8                                                                EDIT1820
  101 CALL MATLD(MATRX,ABC,ILD)                                            EDIT1830
      IF(IABS(ILD).EQ.999) GO TO 108                                       EDIT1840
      IF(ILD.EQ.9) DIAG=.FALSE.                                            EDIT1850
      IF(ILD.EQ.1) CALL MAK(A    ,MATRX,5)                                 EDIT1860
      IF(ILD.EQ.2) CALL MAK(B    ,MATRX,5)                                 EDIT1870
      IF(ILD.EQ.3) CALL MAK(AA   ,MATRX,5)                                 EDIT1880
      IF(ILD.EQ.4) CALL MAK(BB   ,MATRX,5)                                 EDIT1890
      IF(ILD.EQ.5) CALL MAK(AR   ,MATRX,5)                                 EDIT1900
      IF(ILD.EQ.6) CALL MAK(BR   ,MATRX,5)                                 EDIT1910
      IF(ILD.EQ.7) CALL MAK(APRA,MATRX,5)                                  EDIT1920
      IF(ILD.EQ.8) CALL MAK(APRB,MATRX,5)                                  EDIT1930
      IF(IABS(ILD).EQ.9) CALL MAK(D1,MATRX,8)                              EDIT1940
      IF(ILD.EQ.10) CALL MAK(AP   ,MATRX,4)                                EDIT1950
      IF(ILD.EQ.11) CALL MAK(BP   ,MATRX,4)                                EDIT1960
      IF(ILD.EQ.12) CALL MAK(R,MATRX,5)                                    EDIT1970
      GO TO 101                                                            EDIT1980
  108 MAX=5                                                                EDIT1990
      MZ=D1(8,1)                                                           EDIT2000
      APBP=.FALSE.                                                         EDIT2010
      IF(ABC(10).EQ.-99999. .AND. ABC(11).EQ.-99999.) APBP=.TRUE.          EDIT2020
      IF(LATR.OR.LONG) GO TO 117                                           EDIT2030
      IF(A(1,2).GT. .5) GO TO 113                                          EDIT2040
      LATR=.TRUE.                                                          EDIT2050
      GO TO 117                                                            EDIT2060
  113 LONG=.TRUE.                                                          EDIT2070
      DO 114 I=1,12                                                        EDIT2080
  114 LABELS(I)=LONLAB(I)                                                  EDIT2090
      WRITE(3,2007)                                                        EDIT2100
  117 IF(ILD.EQ.-999) LAST=.TRUE.                                          EDIT2110
      IF(ABC(5).NE.-99999.) CALL AMAKE(AR,A)                               EDIT2120
      IF(ABC(6).NE.-99999.) CALL AMAKE(BR,B)                               EDIT2130
      IF(LONG) GO TO 121                                                   EDIT2140
      IF(ABC(9).EQ.-99999.) GO TO 119                                      EDIT2150
      DO 118 I=1,5                                                         EDIT2160
  118 D1(I,I)=D1LAT(I)                                                     EDIT2170
  119 IF(ABC(7).NE.-99999.) CALL AMAKE(APRA,APRLAT)                        EDIT2180
      IF(ABC(8).NE.-99999.) CALL AMAKE(APRB,BPRLAT)                        EDIT2190
      IF(ABC(3).NE.-99999.) CALL AMAKE(AA,AALAT)                           EDIT2200
      IF(ABC(4).NE.-99999.) CALL AMAKE(BB,BBLAT)                           EDIT2210
      IF(XB.NE.0. .OR.ZB.NE.0. .OR.XAY.NE.0. .OR.ZAY.NE.0.)CORECT=.TRUE.EDIT2220
      IF(ABC(12).EQ.-99999.) GO TO 123                                     EDIT2230
      R(2,3)=-IXZ/IX                                                       EDIT2240
      R(3,2)=-IXZ/IZ                                                       EDIT2250
      IF(TEST) CALL ASPIT(R)                                               EDIT2260
  123 IF(.NOT.BOTH) GO TO 122                                              EDIT2270
```

```
      DO 7 I=1,3
    7 ORDER(I)=I+15
      ORDER(4)=12
      DO 9 I=5,11
    9 ORDER(I)=I+14
      ORDER(12)=1
      ORDER(13)=3
      GO TO 122
  121 IF(ABC(7).NE.-99999.) CALL AMAKE(APRA,APRLON)
      IF(ABC(8).NE.-99999.) CALL AMAKE(APRB,BPRLON)
      IF(ABC(3).NE.-99999.) CALL AMAKE(AA,AALON)
      IF(ABC(4).NE.-99999.) CALL AMAKE(BB,BBLON)
      IF(XALF.NE.0. .OR. XAN.NE.0. .OR. ZAX.NE.0.) CORECT=.TRUE.
      IF(ABC(9).EQ.-99999.) GO TO 122
      DO 124 I=1,5
  124 D1(I,I)=D1LON(I)
C*************************************** COMPUTE SIZE OF SYSTEM
C*************************************** AA AND BB TO LOGICAL VARIABLES
  122 CALL INV(R,MAX)
      MX=A(MAX,2)
      MU=B(MAX,2)
      MXP1=MX+1
      MZM=MZ-MX
      DO 150 I=MXP1,MZ
  150 IF(D1(I,I).EQ.0.) VAR(I-MX)=.FALSE.
      JKMM1=0
      DO 120 I=1,MX
      DO 110 J=1,MX
      IF(AA(I,J)) 107,106,107
  106 LAA(I,J)=.TRUE.
      GO TO 110
  107 LAA(I,J)=.FALSE.
      JKMM1=JKMM1+1
  110 CONTINUE
      DO 120 J=1,MU
      IF(BB(I,J)) 112,111,112
  111 LBB(I,J)=.TRUE.
      GO TO 120
  112 LBB(I,J)=.FALSE.
      JKMM1=JKMM1+1
  120 CONTINUE
      JKMM=JKMM1
      DO 125 I=1,MX
  125 IF(ZERO(I)) JKMM1=JKMM1+1
      JKV=JKMM1
      DO 126 I=1,MZM
  126 IF(VAR(I)) JKMM1=JKMM1+1
      JKM=JKMM1+1
      APR(35,1)=JKMM1
      APR(35,2)=JKM
      RETURN
 1000 FORMAT(2(3I2,I3,1X))
 2000 FORMAT(20A4)
 2001 FORMAT(13H  PLOT LIMITS/5X,7HMINIMUM,15F8.2/5X,7HMAXIMUM,15F8.2)
 2002 FORMAT(/10H0 MANEUVER,I4,12H  START TIME,4I5,11H  STOP TIME,4I5)
 2003 FORMAT(1H1,26X,20A4,13X,A10)
 2004 FORMAT(/18H0 INPUT MATRICES :)
```

```
2005 FORMAT(1H1,20X,20A4,10X,A1)/40X,14HNEWTON-RAPHSON,
   -      28H DIGITAL DERIVATIVE MATCHING/60X,10H1 APR 1974)
2006 FORMAT(28H0D1 WILL BE DETERMINED USING,I3,
    -28H PASSES. RELAXATION FACTOR =,F5.2,13H  TOLERANCE =,F5.2)
2007 FORMAT(46H THE A MATRIX INDICATES CASE IS LONGITUDINAL.
    -57HLABELS ABOVE ARE WRONG. APPROPRIATE CORRECTIONS NOW MADE.)
2008 FORMAT(23H0WMAPR WILL BE RUN WITH,I3,25H VALUES.   FIRST 0., THEN,
   -      E9.2,27H. THEREAFTER MULTIPLYING BY,E9.2)
2009 FORMAT( 50H0INPUT DATA (T INDICATES TRUE OR YES, F INDICATES ,
   -      12HFALSE OR NO)/1H0,4X,3A4,5H CASE/16H     DATA SOURCE,
   -      10H    CARD? ,L1,8X,6HTAPE? ,L1/5X,12HDATA RATE IS,F5.0,
   -      57H SAMPLES/SECOND ON SOURCE FILE (IF 0, DETERMINED FROM TIM,
   -      22HES ON THE SOURCE FILE)/10X,26HDIVIDED BY THINNING FACTOR,
   -      3H OF,I3/5X,14HON INPUT TAPE:,I4,
   -      56H DATA WORDS PER RECORD.   SPECIAL SIGNAL ORDER DEFAULT? ,
   -      L1)
2010 FORMAT(/16H0PROGRAM OPTIONS/24H0    APRIORI WEIGHTING =,E8.2,
   -      10X,I3,22H TIME HALVINGS IN EAT./
   -      5X,12HITERATIONS =,I3,32H  (ITERATION WILL STOP IF ERROR ,
   -      36HSUM CHANGES BY LESS THAN A FACTOR OF,E9.2,1H)/5X,
   -      49HCASE WILL BE STOPPED IF ERROR SUM IS GREATER THAN,E9.2)
2011 FORMAT(/7H0OUTPUT/12H0     PLOTS? ,L1,25H  (NO PLOTS UNLESS FINAL ,
   -      22HERROR SUM IS LESS THAN,E9.3,1H)/10X,
   -      52HNUMBER OF CONTROLS AND EXTRA SIGNALS TO BE PLOTTED =,I3/
   -      10X,24HSECONDS PER CENTIMETER =,F5.2/5X,
   -      50HPRINTED FLIGHT AND FINAL COMPUTED TIME HISTORIES? ,L1/5X,
   -      57HEXTRA OUTPUT OF INTERMEDIATE STEPS FOR A DIAGNOSTIC AID? ,
   -      L1/5X,51HPUNCHED FINAL NON-DIMENSIONAL DERIVATIVES AND CONFI,
   -      14HDENCE LEVELS? ,L1/5X,26HPUNCHED FINAL DIMENSIONAL ,
   -      10HMATRICES? ,L1)
2012 FORMAT(/54H0FLIGHT CONDITION AND VEHICLE CHACTERISTICS (0. INDICA,
   -      55HTES VALUE OBTAINED FROM TIME HISTORY ON QBAR,V OR MACH),
   -      /44X,49H(MACH,ALPHA,CG AND PARAM ARE FOR REFERENCE ONLY, ,
   -      20HNOT USED IN PROGRAM)/5X,14HMETRIC UNITS? ,L1/5X,
   -      18HDYNAMIC PRESSURE =,F11.1,6X,10HVELOCITY =,F7.1/5X,
   -      6HMACH =,F6.3,23X,7HALPHA =,F7.2,22H  (IF 999. , OBTAINED ,
   -      18HFROM TIME HISTORY)/5X,19HCENTER OF GRAVITY =,F6.3,10X,
   -      29HOTHER IDENTIFYING PARAMETER =,E10.3/5X,11HWING AREA =,
   -      F7.1,17X,6HSPAN =,F7.2,5X,7HCHORD =,F6.2/5X,4HIX =,F9.1,22X,
   -      4HIY =,F10.1,4X,4HIZ =,F10.1,4X,5HIXZ =,F8.1/5X,8HWEIGHT =,
   -      F9.1/5X,26HINSTRUMENT OFFSETS FROM CG/
   -      10X,53HX-DIRECTION OFFSETS (+ = INSTRUMENT IS FORWARD OF CG)/
   -      14X,5HALPHA,F8.3,4H  AN,F8.3/14X,4HBETA,F9.3,4H  AY,F8.3/
   -      10X,49HZ-DIRECTION OFFSETS ( + = INSTRUMENT IS BELOW CG)/
   -      14X,4HBETA,F9.3,4H  AY,F8.3)
2013 FORMAT(26H0SIGNAL SCALING AND BIASES/9H  SIGNALS,7X,14A8,A4/
   -      10H  VAR BIAS,32X,3(7X,L1)/11H  VAR I.C. ,6X,L1,3(7X,L1)/
   -      12H  FIXED BIAS,11F8.2/12H  SCALE FACT,7F8.2)
     END
```

SUBROUTINE DATA

Description: Subroutine DATA reads the input time histories, performs any scaling and biasing required, and completes the program initialization. Averages of several time histories are obtained for use as default values for input parameters not set.

Programing notes: Comment cards separate major subroutine sections. If this is an intermediate step in the D1 determination or the *a priori* variation option, most of the subroutine is skipped since those sections were executed in the first step; this is true when the formal parameter IN is false.

Important variables —

X — vector containing one time point of the input time histories in degrees.

Z, DCR — vectors containing the input observations and controls in radians.

C — matrix containing factors for nondimensionalizing derivatives.

APR — matrix containing any off-diagonal *a priori* weightings. These weightings would be stored in the upper triangular portion of APR. There are no terms inserted here, but if such terms are desired, they may be inserted and the rest of the program will treat them properly. This matrix is referred to elsewhere in the program as SUM, and the lower triangular portion and the diagonal will be used to store other information.

APRD — vector containing the diagonal *a priori* weightings.

Subroutine listing:

```
      SUBROUTINE DATA(IN)
C
C     READS TIME HISTORIES, FERFORMS VARIOUS INITIALIZATION
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /COM/ NCASE,MZ,NPTS,NPTT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -     D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,RI
      COMMON /TOGIRL/JKM,JKMM,JKMM1,ERRMAX,ZEROIN,XT5,BOUND,APR,NI
     -     ,BIASK,ZERO,APRD,JKV,DIAG
      COMMON /INFO/ HH,NOITER,MX,MXP1,MU,TEST,XBN,ZBX,IPQR,IXYZ,XT3,MZM,
     -     CORECT,BIASKN,PLTMAX,XT4,ERRVEC,PUNCHD,NEAT
      COMMON /DIMENS/ C,E,WQS,THETN
      COMMON /HEADNG/ LABELS,TITLE,JULIAN
      COMMON /TODATA/ S,SPAN,XB,ZB,XAY,CARD,ZAY,APRA,APRB,DCBIAS,
     -     XALF,THIN,TAPE,CBAR,APBP,STC,ETC,BIAS,AR,BR,XAN,ZAX,
     -     SCALE,NREC,ORDER,METRIC,AIX,AIY,AIZ,AIXZ,Q,V,GROSWT
      COMMON /ROUTH/ PUNCH ,PARAM,MACH,ALPHA,CG,AC,BC
      DIMENSION A(5,4),B(5,8),TITLE(20),XT4(3),APRD(35),RECORD(100),
     -     AA(5,4),BB(5,8),X(15),Z(7),E(3,8), AP(4,4),BP(4,8),
     -     EXTRA(4), DCR(8),NPTS(15),D1(8,7),DC(4),
     -     C(3,8) ,ERRVEC(20),APR(35,35),XT3(4),RI(5,4),
     -     XT5(35),AR(5,4),BR(5,8),APRA(5,4),APRB(5,8),AC(5,4),BC(5,8)
      INTEGER T(4),ORDER(15),THIN,STC(15),ETC(15)
      REAL DCBIAS(4),CALIB(7),BIAS(7),LABELS(15),MACH,SCALE(7)
      LOGICAL CORECT,METRIC,CARD,PLOTEM,APBP,AA,BB,TAPE,LAST,DIAG,
     -          BIASKN,ZEROIN,TEST,LONG,LATR,PRINT,IN,BIASK(3),ZERO(4),
     -     PUNCHD,PRNT
      EQUIVALENCE(X(8),DC(1)),(X(12),EXTRA(1))
      DATA STAR/1H*/,BLANK/1H /
      PRNT=PRINT.OR.(NOITER.EQ.0)
      G=32.172
      IF(METRIC) G=9.80665
      RAD=57.2958
      LINE=50
      DO 5 I=1,3
    5 XT4(I)=0.
      DO 10 I=1,7
      CALIB(I)=1./RAD
   10 Z(I)=0.
      CALIB(5)=1.
      DO 20 I=4,8
   20 DCR(I)=0.
      IF(.NOT.LONG) GO TO 50
      XT4(1)=1.
      CALIB(3)=1.
      CALIB(7)=1.
   50 CONTINUE
C*************************************** READ INPUT TIME HISTORY
      IF(.NOT.IN) GO TO 505
      IF(PRNT) WRITE(3,2001)
      NPTT=0
      AMACH=0.
      ALFA=0.
      AV=0.
      AQBAR=0.
      PHI=0.
```

```
      THETA=0.
      VEL=V
      DO 500 I11=1,NCASE
      ISTMS=STC(I11)
      IETMS=ETC(I11)
      ITHIN=THIN-1
      NPTS(I11)=0
      IF(I11.LE.4) DCR(I11+4)=1.
  260 IF (TAPE) GO TC 240
      READ (1,1001) T,X
      GO TO 250
  240 READ (4) T,(RECORD(I),I=1,NREC)
  250 IF((T(4)+1000*(T(3)+60*T(2)+3600*T(1))).LT.ISTMS) GO TO 26C
      ITST=T(4)
      IF(.NOT.TAPE) GO TO 300
      DO 270 I=1,15
  270 X(I)=RECORD(ORCER(I))
  300 ITM=T(4)+1000*(T(3)+60*T(2)+3600*T(1))
      IF(ITM.GT.IETMS) GO TO 430
      ITHIN=ITHIN+1
      IF(MOD(ITHIN,THIN).NE.0) GO TO 385
          NPTS(I11) = NPTS(I11) + 1
      IF(NPTS(1).NE. 2.OR. SPS.NE.0.) GO TO 309
      I=T(4)-ITST
      IF(I.LT.0) I=I+1000
      HH=((I+2)/5)*5
      HH=HH/1000.
      SPS=1./HH
C************************************** ADD BIASES AND SCALE FACTORS
  309 DO 310 I=1,4
      DC(I)=DC(I)+DCBIAS(I)
  310 DCR(I)=DC(I)/RAD
      DO 315 I=1,MZ
  315 X(I)=X(I)*SCALE(I)+BIAS(I)
      AMACH=AMACH+EXTRA(3)
      AQBAR=AQBAR+EXTRA(4)
      IF (LONG) GO TO 350
      IF(.NOT.CORECT) GO TO 340
      IF( V.EQ.0.) VEL=EXTRA(2)
      X(1)=X(1)-(XB*X(3)-ZB*X(2))/VEL
  340 ALFA=ALFA+EXTRA(1)
      AV=AV+EXTRA(2)
      GO TO 360
  350 IF(.NOT.CORECT)  GO TO 355
      IF( V.EQ.0.) VEL=X(3)
      X(1)=X(1)+XALF*X(2)/VEL
 355  ALFA=ALFA+X(1)
      AV=AV+X(3)
      PHI=PHI+EXTRA(1)
      THETA=THETA+X(4)
  360 DO 365 I=1,MZ
  365 Z(I)=X(I)*CALIB(I)
      ITIME=T(4)+1000*(T(3)+100*T(2)+10000*T(1))
      WRITE (7) ITIME,Z,DCR,EXTRA
      IF(.NOT.PRNT) GO TO 375
      IF(MOD(LINE,50).EQ.0)
     -WRITE(3,2003)  TITLE,JULIAN,GROSWT,AIX,AIZ,AIXZ,AIY,Q,V,LABELS
```

```
      WRITE(3,2010)T,X
      LINE=LINE+1
  375 IF(ITM.EQ.IETMS) GO TO 430
  385 IF (CARD) GO TO 400
      READ (4) T,(RECORD(I),I=1,NREC)
      DO 390 I=1,15
  390 X(I)=RECORD(ORDER(I))
      GO TO 300
  400 READ (1,1001) T,X
      GO TO 300
  430 IF(NPTS(I11).GT.0) GO TO 435
      WRITE(3,2000)I11
      STOP
  435 NPTT=NPTT+NPTS(I11)
      WRITE(3,2007)I11,NPTS(I11)
  500 CONTINUE
      ANPT=FLOAT(NPTT)
      IF(MACH.EQ.0.) MACH=AMACH/ANPT
      IF(ALPHA.EQ.999.) ALPHA=ALFA/ANPT
      IF(V.EQ.0.) V=AV/ANPT
      IF(Q.EQ.0.) Q=AQBAR/ANPT
      VOG=V/G
      AM=GROSWT*VOG/(Q*S)
      V2=2.*V
      IF (LONG) GO TO 170
C*************************************** LATERAL SETUP
      XAN=-ZAY
      ZAX=XAY
      IPQR=3
      IXYZ=1
      P1=VOG
      P3=1.
      AP3=1.
      QSB=Q*S*SPAN
      QSBB=QSB*SPAN
      C(1,2)=1.
      C(2,2)=V2*AIX/QSBB
      C(3,2)=V2*AIZ/QSBB
      C(1,3)=0.
      C(2,3)=C(2,2)
      C(3,3)=C(3,2)
      C(1,1)=AM/RAD
      C(2,1)=AIX/(QSB*RAD)
      C(3,1)=AIZ/(QSB*RAD)
      DO 160 I=1,3
      C(I,8)=C(I,1)*RAD
      DO 160 J=4,7
  160 C(I,J)=C(I,1)
      GO TO 200
C*************************************** LONGITUDINAL SETUP
  170 QSCI=Q*S*CBAR/AIY
      THETA=THETA/ANPT
      WQS=COS(THETA/RAD)*COS(PHI/(RAD*ANPT))*GROSWT/(Q*S)
      IPQR=2
      IXYZ=3
      P1=-VOG
      P3=1./G
```

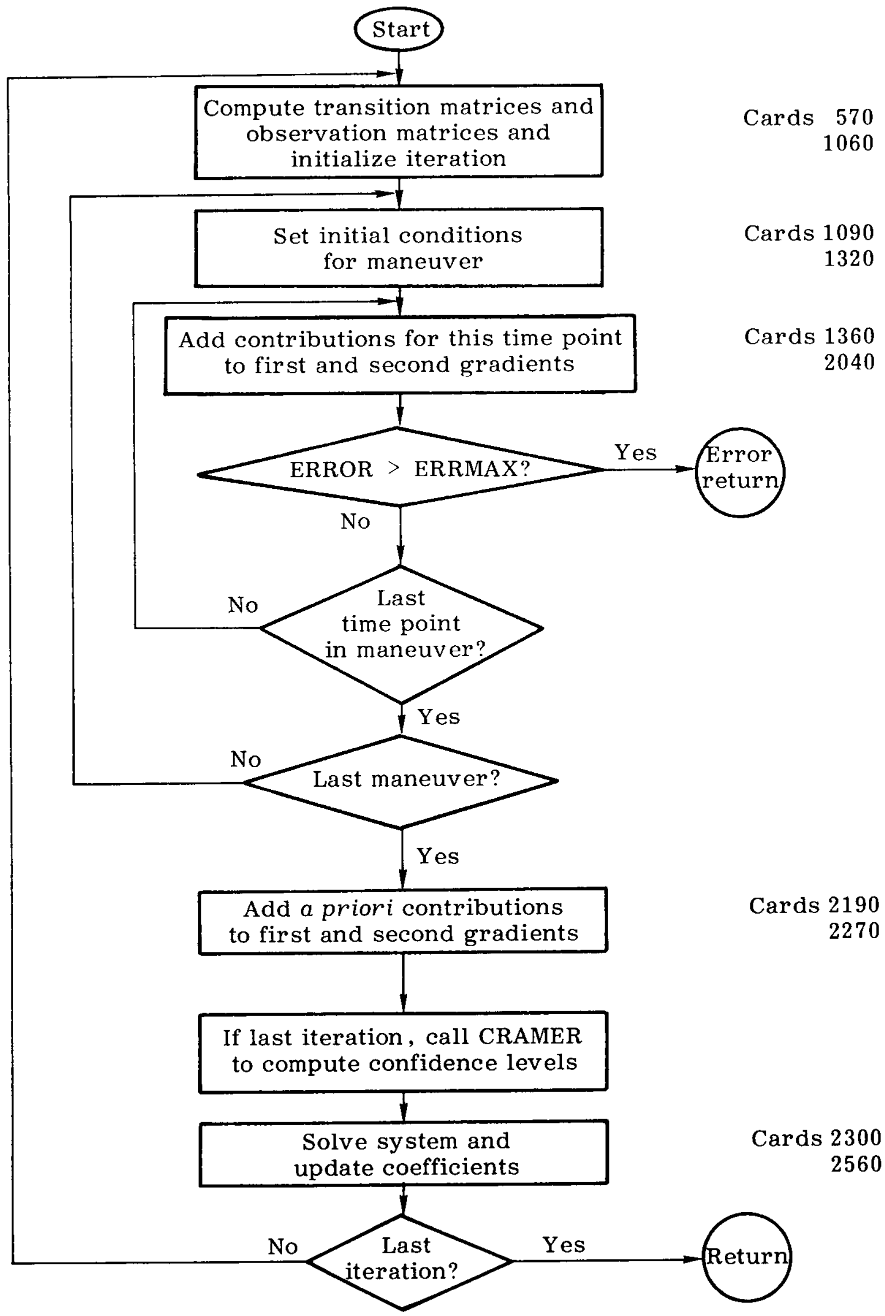
```
      AP3=0.
      C(1,1)=AM/RAD
      C(2,1)=1./(QSCI*RAD)
      C(3,1)=C(1,1)/V
      C(1,2)=0.
      C(2,2)=V2/(QSCI*CBAR)
      C(3,2)=C(1,2)
      DO 180 I=1,3
      C(I,8)=C(I,1)*RAD
      C(I,3)=C(I,8)*V/2.
      DO 180 J=4,7
  180 C(I,J)=C(I,1)
      THETN=THETA*C(1,1)
C     SET E=@@*@@ IF DERIVATIVE IS FIXED, OTHERWISE E=@@ @@
  200 DO 220 I=1,3
       DO 210 J=1,3
      E(I,J)=STAR
      IF(.NOT.AA(I,J)    ) E(I,J)=BLANK
  210 CONTINUE
      DO 220 J=4,8
      K=J-3
      E(I,J)=STAR
      IF(.NOT.BB(I,K)    ) E(I,J)=BLANK
  220 CONTINUE
      MAX=8
C**************************************** FORM AP AND BP IF NOT READ IN
      IF (APBP) GO TO 129
      DO 112 J=1,MU
      BP(1,J)=P1
      BP(2,J)=1.
  112 BP(3,J)=P3
      DO 114 J=1,MX
      AP(1,J)=0.
      AP(2,J)=1.
  114 AP(3,J)=AP3
      AP(1,1)=P1
      AP(3,1)=P3
  129 CONTINUE
      XBN=XAN/G
      ZBX=ZAX/G
C**************************************** STORE APRIORI WEIGHTINGS
  505 MAX=35
      CALL AZOT(APR)
      DO 510 I=1,35
      APRO(I)=0.
  510 XT5(I)=0.
      IF(WMAPR.EQ.0.) RETURN
      K=0
      DO 525 I=1,MX
      DO 520 J=1,MU
      IF(BB(I,J)         ) GO TO 520
      K=K+1
      XT5(K)=B(I,J)-BR(I,J)
      APRO(K)=APRB(I,J)*WMAPR
  520 CONTINUE
      DO 525 J=1,MX
      IF(AA(I,J)         ) GO TO 525
```

```
      K=K+1                                                              DATA2280
      XT5(K)=A(I,J)-AR(I,J)                                              DATA2290
      APRD(K)=APRA(I,J)*WMAPR                                            DATA2300
  525 CONTINUE                                                           DATA2310
 1001 FORMAT(3I2,I4,7F10.4/8F10.4)                                       DATA2320
 2000 FORMAT(14H0TIME INTERVAL,I3,10H NOT FOUND)                         DATA2330
 2001 FORMAT(55H0INPUT TIME HISTORY WITH BIASES AND SCALE FACTORS APPLI,DATA2340
     -       38HED AND VANE CORRECTIONS ADDED FOLLOWS.)                  DATA2350
 2003 FORMAT(1H1,26X,20A4,13X,A10/4H0W =,F8.1,6H  IX =,F9.1,6H  IZ =,    DATA2360
     -       F10.1,7H  IXZ =,F7.1,6H  IY =,F9.1,8H  QBAR =,F7.2,5H  V =,  DATA2370
     -       F8.2/5X,4HTIME,6X,14A8,A4)                                  DATA2380
 2007 FORMAT(1H0,40X,35HTOTAL NUMBER OF POINTS FOR MANEUVER,I3,2H =,I6)  DATA2390
 2010 FORMAT(1X,3I2,I3,2X,12F8.3,F8.1,F8.3,F8.2)                         DATA2400
      RETURN                                                             DATA2410
      END                                                                DATA2420
```

SUBROUTINE AGIRL

Description: Subroutine AGIRL performs the parameter estimation. Almost all the routine is skipped if NOITER = 0.

Flow chart:



Programing notes: For derivation of the form of the first and second gradients, see reference 3.

Important variables –

SUM – contains second gradient in lower triangular and diagonal locations, and off-diagonal *a priori* weightings in upper triangular. Diagonal *a priori* weightings are in APRD. The first gradient appears as an extra column in SUM (the JKM$^{\text{th}}$ column). The SUM matrix is printed each iteration when TEST = T.

XJI – $\nabla_c\left(z_i - y_i\right)^*$

RIA – $R^{-1}A$

RIB – $R^{-1}B$

PHI1 – $e^{R^{-1}A\Delta t}$

APHI – $\left(\int_0^{\Delta t} e^{R^{-1}A\tau} d\tau\right)R^{-1}$

BPHI – (APHI) (B)

AAP, BBP – observation matrices formed from A and AP or B and BP, with any terms for accelerometer offset from the center of gravity added. (These matrices are referred to as G and H in the derivation.)

RIAP – array of partial derivatives of AAP with respect to A.

$$\text{RIAP(I,J,K)} = \frac{\partial \text{AAP(I,K)}}{\partial \text{A(J,K)}}.$$

RIBP – array of partial derivatives of BBP with respect to B.

$$\text{RIBP(I,J,K)} = \frac{\partial \text{BBP(I,K)}}{\partial \text{B(J,K)}}.$$

Z, U – measured values of observations and controls.

XT1, XT2 – computed values for observations.

XT3 – variable initial conditions on the states.

XT4 – variable bias on the observations other than states.

XT5 – difference between the estimated coefficients and the *a priori* values.

PB – solution vector for the change in the estimates of the coefficients.

MX – number of states.

MZ – number of observations.

Subroutine listing:

```
      SUBROUTINE AGIRL
C
C     CORE SUBROUTINE - ITERATIVE LOCP
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /COM/ NCASE,MZ,NPTS,NPTT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -     D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      COMMON /TOGIRL/JKM,JKMM,JKMM1,ERRMAX,ZEROIN,XT5,BOUND,SUM,NI
     -     ,BIASK,ZERO,APRD,JKV,DIAG
      COMMON /INFO/ HH,NOITER,MX,MXP1,MU,TEST,XAN,ZAX,IPQR,IXYZ,XT3,MZM,
     -     CORECT,BIASKN,PLTMAX,XT4,ERRVEC,PUNCHD,NEAT
      COMMON /HEADNG/  LABELS,TITLE,JULIAN
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,RI
      COMMON /ROUTH/ PUNCH,PARAM,MACH,ALP,CG,AC,BC
      COMMON /DIMENS/ C,CC,E,WQS,THETN
      REAL XT3(4),XT4(3),XT5(35),PB(35), APRC(35),LAEELS(15)
      REAL U12(8),U23(8),BPHI(5,8),EXTRA(4),AC(5,4),BC(5,8)
      LOGICAL AA,BB,TEST,ZEROIN,BIASKN,CORECT,LATR,ERSTOP,PUNCHD
     -     ,ZERO(4),BIASK(3),PRINT,LAST,DIAG,E(24),PUNCH,PLOTEM
      DIMENSION A( 5,4 ), B( 5,8 ), SUM(35,35),PHI1( 5,4 ), U( 8,3 ),
     -         AA( 5,4 ),BB( 5,8 ),RI(5,4),    APHI( 5,4 ), Z( 8,3 ),
     -         AP( 4,4 ),BP( 4,8 ), XJI(35,8 ),DUM1( 5,4 ),D1( 8,7 ),
     -                    XT12(4),AAP(3,4),BBP(3,8),RIA(5,4),RIB(5,8),
     -      XT1(7),NPTS(15),ERRVEC(20),XT2(7),D2(8),TITLE(20),XT6(4),
     -     RIBP(4,4,8),RIAP(4,4,4),XJID1(35,7),C(3,3),CC(3,5)
      EQUIVALENCE (APHI(5,3),APHIL),(PHI1(5,3),PHI1L),(BPHI(5,3),BPHIL)
      DATA PHI1L/4HPHI1/,APHIL/4HAPHI/,BPHIL/4HPHIB/
      ANPT=FLOAT(NPTT)
      ERMX=ERRMAX*ANPT
      EN=1.E+50
      ERSTOP=.FALSE.
      DO 7 I=1,JKMM1
    7 PB(I)=0.
      DO 2 I = 1,MX
    2 XT3(I)=0.
      IF (NOITER.EQ.0) GO TO 600
      WRITE(3,1000)TITLE,JULIAN,MACH,ALP,PARAM,CG
      CALL DERIV(LONG)
      DO 320 I=1,MX
      DO 320 J=1,MX
      DO 310 K=1,MU
  310 RIBP(I,J,K)=RI(I,J)*BP(I,K)
      DO 320 K=1,MX
  320 RIAP(I,J,K)=RI(I,J)*AP(I,K)
C     TERMS FOR ACCELEROMETER OFFSET FROM CG
      IF(.NOT.CORECT) GO TO 350
      DO 340 J=1,MX
      DO 330 K=1,MU
      RIBP(1,J,K)=RIBP(1,J,K)+XAN*RI(2,J)
  330 RIBP(IXYZ,J,K)=RIBP(IXYZ,J,K)+ZAX*RI(IPQR,J)
      DO 340 K=1,MX
      RIAP(1,J,K)=RIAP(1,J,K)+XAN*RI(2,J)
  340 RIAP(IXYZ,J,K)=RIAP(IXYZ,J,K)+ZAX*RI(IPQR,J)
  350 CONTINUE
      WRITE(3,103)JKMM1
C**************************************  ITERATION LOOP
      DO 32 LL = 1,NOITER
```

```
      MAX    = 5
      CALL ASPIT(A)
      CALL ASPIT(B)
      CALL AMULT(RI,A,RIA)
      CALL AMULT(RI,B,RIB)
C     COMPUTE A*AP AND B*BP          ADD TERMS FOR CG SHIFT IF NEEDED
      DO 45 I=1,3
      DO 40 J=1,MX
   40 AAP(I,J)=RIA(I,J)*AP(I,J)
      DO 45 J=1,MU
   45 BBP(I,J)=RIB(I,J)*BP(I,J)
      IF(.NOT.CORECT) GO TO 50
      DO 46 J=1,MX
      AAP(1,J)=AAP(1,J)+XAN*RIA(2,J)
   46 AAP(IXYZ,J)=AAP(IXYZ,J)+ZAX*RIA(IPQR,J)
      DO 47 J=1,MU
      BBP(1,J)=BBP(1,J)+XAN*RIB(2,J)
   47 BBP(IXYZ,J)=BBP(IXYZ,J)+ZAX*RIB(IPQR,J)
   50 REWIND 7
      CALL AEAT(RIA,HH,PHI1,APHI,DUM1,SUM,NEAT)
      CALL AMULT(APHI,RI,DUM1)
      CALL AMAKE(APHI,DUM1)
      CALL AMULT(APHI,B,BPHI)
      IF(.NOT.TEST) GO TO 51
      CALL ASPIT(PHI1)
      CALL ASPIT(APHI)
      CALL ASPIT(BPHI)
   51 DO 53 I=1,MX
      DO 53 J=1,I
      TEMP=PHI1(I,J)
      PHI1(I,J)=PHI1(J,I)
   53 PHI1(J,I)=TEMP
      MAX    = NI
      DO 60 I=1,JKM
      DO 60 J=1,I
   60 SUM(I,J)=0.
      DO 52 I=1,8
   52 D2(I) = 0.0
C     VARIABLE BIAS
      IF(.NOT.BIASKN) GO TO 3
      IBIAS=JKV
      DO 16 I = 1,MZM
      IF(.NOT.BIASK(I)) GO TO 16
      IBIAS  = IBIAS + 1
      DO 15 J = 1,MZ
   15 XJI(IBIAS,J)=0.
      XJI(IBIAS,I+MX)=1.
   16 CONTINUE
      WRITE(3,1001)(LABELS(I),I=MXP1,MZ)
      WRITE(3,102)(XT4(I),I=1,MZM)
C************************************  CASE LOOP
    3 DO 26 LM = 1,NCASE
      NNM1=NPTS(LM)-1
      XJI(NI,1)=JKV
      XJI(NI,2)=MX
      CALL AZOT(XJI)
      READ (7) IT,XT1,(U(K,1),K=1,8),EXTRA
```

```
      READ (7) IT,XT2,(U(K,2),K=1,8),EXTRA
C     VARIABLE INITIAL CONDITION
      IF(.NOT.ZEROIN) GO TO 6
      IC=JKMM
      DO 4 I = 1,MX
      IF(.NOT.ZERO(I)) GO TO 4
      IC     = IC + 1
      XJI(IC,I)=1.
      XT1(I) = XT1(I) + XT3(I)
      XT2(I) = XT2(I) + XT3(I)
    4 CONTINUE
      IF(LM.NE.1) GO TO 6
      WRITE(3,1001)(LABELS(I),I=1,MX)
      WRITE(3,108) (XT3(I),I=1,MX)
    6 DO 8 I=1,MZ
      Z(I,1) = XT1(I)
    8 Z(I,2) = XT2(I)
      IF(TEST) WRITE(3,111)(XT1(I),I=1,MZ)
      IF(TEST) WRITE(3,111)(XT2(I),I=1,MZ)
C*************************************** TIME LOOP
C*************************************** COMPUTE GRADIENT AND HESSIAN
      DO 10025 IP = 2,NNM1
      READ (7) IT,(Z(K,3),K=1,7),(U(J,3),J=1,8),EXTRA
      IF(LL.EQ.1) GO TO 203
      DO 201 I=1,MX
      XT12(I)=.5*(XT1(I)+XT2(I))
  201 XT6(I)=XT2(I)
      GO TO 205
  203 DO 204 I=1,MX
      XT12(I)=.5*(Z(I,2)+Z(I,1))
      XT6(I)=Z(I,2)
      Z(I,1) = Z(I,2)
  204 Z(I,2) = Z(I,3)
  205 CONTINUE
      DO 206 I=1,MU
      U12(I)=.5*(U(I,1)+U(I,2))
      U23(I)=.5*(U(I,2)+U(I,3))
      U(I,1)=U(I,2)
  206 U(I,2)=U(I,3)
      DO 210 J=MXP1,MZ
      DO 210 JK=1,JKV
  210 XJI(JK,J) = 0.0
      DO 11 I = 1,MX
      XT1(I)=XT2(I)
   11 XT2(I)=0.
      CALL AMULT(XJI,PHI1,XJID1)
      CALL AMAKE(XJI,XJID1)
      JK     = 0
      DO 14 J = 1,MX
      DO 12 K = 1,MU
      XT2(J)=XT2(J)+BPHI(J,K)*U23(K)
      IF (BB(J,K)) GO TO 12
      JK     = JK + 1
      DO 115 I=1,MX
      XJI(JK,I+MX)=RIBP(I,J,K)*U(K,1)
  115 XJI(JK,I)=XJI(JK,I)+U12(K)*APHI(I,J)
   12 CONTINUE
```

```
      DO 14 K = 1,MX
      XT2(J)=XT2(J)+PHI1(K,J)*XT1(K)
      IF(AA(J,K)) GO TO 14
      JK      = JK + 1
      DO 125 I=1,MX
      XJI(JK,I+MX)=PIAP(I,J,K)*XT6(K)
  125 XJI(JK,I)=XJI(JK,I)+XT12(K)*APHI(I,J)
   14 CONTINUE
      DO 19 L = MXP1,MZ
      LMMX=L-MX
      DO 17 JK=1,JKV
      DO 17 K = 1,MX
   17 XJI(JK,L)=XJI(JK,L) + XJI(JK,K)*AAP(LMMX,K)
      XT2(L)=XT4(LMMX)
      DO 18 K = 1,MU
   18 XT2(L)=XT2(L)+BBP(LMMX,K)*U(K,2)
      DO 19 K = 1,MX
   19 XT2(L)=XT2(L)+AAP(LMMX,K)*XT2(K)
      DO 20 J = 1,MZ
      XJI(JKM,J) = Z(J,3) - XT2(J)
   20 D2(J)      = XJI(JKM,J)**2 + D2(J)
      IF(TEST) WRITE(3,111)(XT2(I),I=1,MZ)
      IF(DIAG) GO TO 62
      MIX=8
      XJI(NI,1)=JKM
      XJI(NI,2)=MZ
      CALL AMULT(XJI,D1,XJID1)
      XJI(NI,1)=JKV
      XJI(NI,2)=MX
      MIX=5
      GO TO 63
   62 CALL DMULT(XJI,D1,XJID1,JKM,MZ)
   63 CALL SUMULT(XJI,XJID1,SUM,JKM,MZ)
      IF(SUM(JKM,JKM).GT.ERMX) GO TO 510
10025 CONTINUE
   26 CONTINUE
C*************************************** END OF TIME AND CASE LOOPS
      ERRSUM=SUM(JKM,JKM)/ANPT
      ERRVEC(LL)=ERRSUM
      WRITE(3,104)ERRSUM
      IF(ABS((EN-ERRSUM)/EN).LT.BOUND) ERSTOP=.TRUE.
      EN=ERRSUM
      DO 64 I=1,MZ
      XT1(I)=D2(I)/ANPT
   64 D2(I)=XT1(I)*D1(I,I)
      WRITE(3,105)(XT1(I),I=1,MZ)
      WRITE(3,106)(D2(I),I=1,MZ)
C*************************************** SOLUTION OF SYSTEM
      DO 28 I =1,JKMM1
      XT5(I) = XT5(I) + PB(I)
      SUM(I,JKM)=SUM(JKM,I)-XT5(I)*APRD(I)
      SUM(I,I)=SUM(I,I)+APRD(I)
      IM1=I-1
      IF(IM1.EQ.0) GO TO 28
      DO 27 J=1,IM1
   27 SUM(I,J)=SUM(I,J)+SUM(J,I)
   28 CONTINUE
```

```
      IF (TEST) CALL ASPIT(SUM)
      IF(ERSTOP.OR.(LL.EQ.NOITER)) CALL CRAMER(SUM,APRO,MU,MZ,ERRSUM)
      CALL SOLVE(SUM,PB)
      IF(TEST) WRITE(3,107)(PB(I),I=1,JKMM1)
C************************************** UPDATE COEFFICIENTS
      IJ          = 0
      DO 31 I = 1,MX
      DO 30 J = 1,MU
      IF (BB(I,J)       ) GO TO 30
      IJ            = IJ + 1
      B(I,J)        = PB(IJ) + B(I,J)
   30 CONTINUE
      DO 31 J = 1,MX
      IF (AA(I,J)       ) GO TO 31
      IJ            = IJ + 1
      A(I,J)        = PB(IJ) + A(I,J)
   31 CONTINUE
      IF(.NOT.ZEROIN) GO TO 35
      DO 34 I=1,MX
      IF(.NOT.ZERO(I)) GO TO 34
      IJ=IJ+1
      XT3(I)=XT3(I)+PB(IJ)
   34 CONTINUE
   35 IF (.NOT.BIASKN ) GO TO 37
      DO 36 I=1,MZM
      IF (.NOT.BIASK(I)) GO TO 36
      IJ=IJ+1
      XT4(I) = XT4(I) + PB(IJ)
   36 CONTINUE
   37 WRITE(3,101)LL
      IF (ERSTOP) GO TO 38
   32 CONTINUE
C************************************** END OF ITERATION LOOP
      GO TO 500
   38 WRITE(3,110)BOUND
      NOITER=LL
  500 MAX=5
      WRITE(3,2003)
      CALL ASPIT(AC)
      CALL ASPIT(BC)
      WRITE(3,2006)
      DO 508 I=1,3
      DO 507 J=1,3
  507 AC(I,J)=AC(I,J)*C(I,J)
      DO 508 J=1,5
  508 BC(I,J)=BC(I,J)*CC(I,J)
      CALL ASPIT(AC)
      CALL ASPIT(BC)
      RETURN
  510 WRITE(3,2001)ERRMAX
      NOITER=LL
      ERRVEC(LL)=ERRMAX
  101 FORMAT(//50X,16HITERATION NUMBER,I4,10H COMPLETED)
  102 FORMAT(15H VARIABLE BIAS ,3E12.4)
  103 FORMAT(1H+,100X,20HNUMBER OF UNKNOWNS =,I3/1H0,20X,
     -       23HENTERING ITERATION LOOP/25H0 DIMENSIONAL DERIVATIVE ,
     -       39HMATRICES PER RADIAN. BIASES IN RADIANS.//)
```

```
 104 FORMAT(95X,20HWEIGHTED ERROR SUM =,E12.4)
 105 FORMAT(7H ERRORS/1X,11E12.4)
 106 FORMAT(16H WEIGHTED ERRORS/1X,11E12.4)
 107 FORMAT(12H PB VECTOR =,10E12.4/(12X,10E12.4))
 108 FORMAT(15H VARIABLE IC    ,4E12.4)
 110 FORMAT(37H0 ITERATION TERMINATING, ERROR WITHIN,F9.6,8H  BOUND.)
 111 FORMAT(1X,7E12.4)
1000 FORMAT(1H1,26X,20A4,13X,A10/1H0,10X,15HSTARTING VALUES,5X,
   -      6HMACH =,F6.3,5X,7HALPHA =,F7.2,5X,7HPARAM =,F10.4,5X,
   -      4HCG =,F6.3)
1001 FORMAT(15X,7A12)
2001 FORMAT(40H0ITERATION TERMINATING. MAXIMUM ERROR OF,E10.2,
   -      9H EXCEEDED/27H0INPUT TIME HISTORY FOLLOWS)
2003 FORMAT(45H0CONFIDENCE LEVELS FOR NEXT TO LAST ITERATION/
   -      5X,13H(DIMENSIONAL)/)
2006 FORMAT(22H0     (NON-DIMENSIONAL))
 600 RETURN
     END
```

SUBROUTINE OUTPUT

Description: Subroutine OUTPUT provides the final output in several forms. The time histories are computed with the final derivative estimates and may be printed or written on a file for plotting. Final derivative estimates are also printed and, if requested, punched on cards. An error exit section to print the input time history is entered if PLTMAX or ERRMAX was exceeded.

Programing notes: Time history data for plotting are written on unit 8. The time histories are always computed to determine the final error sum, even if neither printout nor plots are requested. Most variable names are similar to those in subroutine AGIRL. ERRVEC contains the error sum from each iteration in AGIRL for the convergence summary.

Subroutine listing:

```
      SUBROUTINE OUTPUT(D2)
C
C     COMPUTES FINAL TIME HISTORY, OUTPUT MODES AS SPECIFIED
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,RI
      COMMON /COM/ NCASE,MZ,NPTS,NPTT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -     D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      COMMON /INFO/ HH,NOITER,MX,MXP1,MU,TEST,XAN,ZAX,IPQR,IXYZ,XT3,MZM,
     -     CORECT,BIASKN,PLTMAX,XT4,ERRVEC,PUNCHD,NEAT
      COMMON/HEADNG/ LABELS,TITLE,JULIAN
      COMMON /DIMENS/ C,CC,E,WQS,THETN
      COMMON /ROUTH/ PUNCH ,PARAM,MACH,ALP,CG,AC,BC
      DIMENSION A(5,4),B(5,8),AA(5,4),BB(5,8),AP(4,4),BP(4,8),D1(8,7),
     -               XT4(3),NPTS(15),PHI1(5,4),APHI(5,4),DUM1(5,4),
     -     XT1(7),XT2(7),D2(7),Z(7),BJI(4),TITLE(20),U1(8),U2(8),
     -     ERRVEC(20),AAP(3,4),BBP(3,8),XT6(7),U(4),AC(5,4),BC(5,8)
      LOGICAL TEST,CCRECT,BIASKN,LATR,PUNCH,PLOTEM,E(24),PRINT,LAST,
     -     OUTPT,PUNCHD,LONG
      REAL CALIB(7),LABELS(15),MACH,C(3,3),CC(3,5),U3(4),Y(7),BIASD(4)
     -     ,RI(5,4),RIA(5,4),RIB(5,8),EXTRA(4),EXTR1(4),XT3(4)
      DATA PHI1L/4HPHI1/,APHIL/4HAPHI/,ALAT/4HLATR/,ALON/4HLONG/
      RAD=57.2958
      DO 5 I=1,7
    5 CALIB(I)=1./RAD
      CALIB(5)=1.
      IF(LATR) GO TO 7
      CALIB(3)=1.
      CALIB(7)=1.
    7 IF(NOITER.EQ.0) GO TO 8
      IF(ERRVEC(NOITER).GE.PLTMAX) GO TO 450
    8 PHI1(5,3)=PHI1L
      APHI(5,3)=APHIL
      OUTPT=PRINT.OR.PLOTEM
      REWIND 7
      MAX=5
      WRITE(3,1000)TITLE,JULIAN
      WRITE(3,2000)MACH,ALP,PARAM,CG
      CALL DERIV(LONG)
      DO 10 I=1,MZM
   10 BIASD(I)=XT4(I)/CALIB(I+MX)
      IF(BIASKN) WRITE(3,1003)(XT4(I),I=1,MZM)
C************************************** FINAL TIME HISTORY
      CALL AMULT(RI,A,RIA)
      CALL AMULT(RI,B,RIB)
      CALL AEAT(RIA,HH,PHI1,APHI,DUM1,BBP,NEAT)
      CALL AMULT(APHI,RI,DUM1)
      CALL AMAKE(APHI,DUM1)
      IF (.NOT.TEST    ) GO TO 60
      CALL ASPIT(APHI)
      CALL ASPIT(PHI1)
   60 DO 70 I=1,MZ
   70 D2(I)=0.
      DO 55 I=1,3
      DO 52 J=1,MX
   52 AAP(I,J)=RIA(I,J)*AP(I,J)
      DO 55 J=1,MU
```

```
   55 BBP(I,J)=RIB(I,J)*BP(I,J)
      IF(.NOT.CORECT) GO TO 69
      DO 61 J=1,MX
      AAP(1,J)=AAP(1,J)+RIA(2,J)*XAN
   61 AAP(IXYZ,J)=AAP(IXYZ,J)+ZAX*RIA(IPQR,J)
      DO 62 J=1,MU
      BBP(1,J)=BBP(1,J)+XAN*RIB(2,J)
   62 BBP(IXYZ,J)=BBP(IXYZ,J)+ZAX*RIB(IPQR,J)
   69 CONTINUE
      ERRSUM=0.
C*************************************** CASE LOOP
      DO 200 LM=1,NCASE
      NNM1=NPTS(LM)-1
      READ (7) IT,XT6,U2,EXTRA
      READ (7) IT1,XT2,U1,EXTR1
      DO 75 I=1,MX
      Y(I)=XT6(I)+XT3(I)
   75 XT1(I)=XT2(I)+XT3(I)
      IF(.NOT.OUTPT) GO TO 95
      DO 76 I=MXP1,MZ
      Y(I)=XT6(I)
   76 XT1(I)=XT2(I)
      DO 80 I=1,MZ
      Z(I) = XT6(I)/CALIB(I)
      Y(I)=Y(I)/CALIB(I)
      XT2(I)=XT2(I)/CALIB(I)
   80 XT6(I) = XT1(I)/CALIB(I)
      DO 91 I=1,4
      U3(I)=U2(I)*RAD
   91 U(I)=U1(I)*RAD
      IF(.NOT.PRINT) GO TO 93
      WRITE(3,1000)TITLE,JULIAN
      IF(LM.EQ.1) WRITE(3,2005)
      WRITE(3,2004)(LABELS(I),I=1,MZ)
      WRITE(3,113)IT,(Z(I),I=1,MZ)
      WRITE(3,113)IT1,(XT6(I),I=1,MZ)
      LINE=2
      IF(.NOT.PLOTEM) GO TO 95
   93 WRITE (8) Y,Z,U3,EXTRA
      WRITE (8) XT6,XT2,U,EXTR1
C*************************************** TIME LOOP
   95 DO 200 IP=2,NNM1
      READ (7) IT,Z,U2,EXTRA
      DO 110 I=1,MX
      BJI(I)=0.
      XT2(I)=0.
      DO 110 J=1,MU
  110 BJI(I)=BJI(I)+B(I,J)*(U2(J)+U1(J))*.5
      DO 120 J=1,MX
      DO 120 K=1,MX
  120 XT2(J) = XT2(J) + BJI(K)*APHI(J,K)  +  XT1(K)*PHI1(J,K)
      DO 140 L=MXP1,MZ
      LMMX=L-MX
      XT2(L)=XT4(LMMX)
      DO 130 K=1,MU
  130 XT2(L) = XT2(L) + U2(K)*BBP(LMMX,K)
      DO 140 K=1,MX
```

```
  140 XT2(L) = XT2(L) + XT2(K)*AAP(LMMX,K)
      DO 150 J=1,MZ
      XT1(J) = XT2(J)
  150 D2(J) = D2(J) + (Z(J)-XT2(J))**2
      IF(.NOT.OUTPT) GO TO 195
      DO 170 I=1,MZ
      Z(I)=Z(I)/CALIB(I)
  170 Y(I)=XT2(I)/CALIB(I)
      DO 191 I=1,4
  191 U(I)=U2(I)*RAD
      IF(PLOTEM) WRITE (8) Y,Z,U,EXTRA
      IF(.NOT.PRINT) GO TO 195
      IF(LINE .LT. 50) GO TO 190
      LINE = 0
      WRITE(3,1000)TITLE,JULIAN
      WRITE(3,2004)(LABELS(I),I=1,MZ)
  190 LINE = LINE+1
      WRITE(3,113)IT,(Y(I),I=1,MZ)
  195 DO 200 K=1,MU
      U1(K) = U2(K)
  200 CONTINUE
C***************************************** END LOOPS
      WRITE(3,2002)
      CALL ASPIT(A)
      CALL ASPIT(B)
C***************************************** PUNCHED OUPUT AS DESIRED
      IF(.NOT.PUNCHD) GO TO 300
      CALL PLOP(A)
      CALL PLOP(B)
  300 IF(.NOT.PUNCH) GO TO 400
      DO 320 I=1,3
      DO 310 J=1,3
  310 A (I,J)=A (I,J)*C(I,J)
      DO 320 J=1,5
  320 B (I,J)=B (I,J)*CC(I,J)
      A(5,1)=3.
      B(5,1)=3.
      TYPE=ALAT
      IF(.NOT.LONG) GO TO 330
      TYPE=ALON
C     DETRIM AND CZ (GOOD ONLY FOR 2 DEGREE OF FREEDOM WITH NO EXTRA
C                   CONTROLS.)
      B(2,5)=-(A(2,1)*ALP+B(2,5))/B(2,1)
      B(1,5)=B(1,5)+A(1,1)*ALP+B(1,1)*B(2,5)-WQS
  330 WRITE(2,2001)TYPE,(TITLE(I),I=1,9),MACH,ALP,PARAM,CG
      CALL PLOP(A )
      CALL PLOP(B )
      CALL PLOP(AC)
      CALL PLOP(BC)
  400 IF(.NOT.BIASKN) GO TO 209
      WRITE(3,1004)(LABELS(I),I=MXP1,MZ)
      WRITE(3,1003) (BIASD(I),I=1,MZM)
  209 DO 210 I=1,MZ
      XT1(I)=D2(I)/FLOAT(NPTT)
      D2(I)=XT1(I)*D1(I,I)
  210 ERRSUM = ERRSUM + D2(I)
      WRITE(3,1001)ERRSUM
```

```
      WRITE(3,100)
      WRITE(3,105)(XT1(I),I=1,MZ)
      WRITE(3,106)
      WRITE(3,105)(D2(I),I=1,MZ)
      IF(NOITER.NE.0) WRITE(3,108)(ERRVEC(I),I=1,NOITER),ERRSUM
      IF(ERRSUM.LT.PLTMAX .OR. .NOT.PLOTEM) RETURN
  450 WRITE(3,1002)PLTMAX
      WRITE(3,1000)TITLE,JULIAN
      WRITE(3,2004)(LABELS(I),I=1,MZ)
      PLOTEM=.FALSE.
      REWIND 7
      DO 500 I=1,NPTT
      READ (7) IT,Z,U,EXTRA
      DO 460 J=1,7
  460 Z(J)=Z(J)/CALIB(J)
      DO 470 J=1,4
  470 U(J)=U(J)*RAD
  500 WRITE(3,113)IT,Z,U
  100 FORMAT(7H ERRORS)
  105 FORMAT (1X,11E12.4)
  106 FORMAT(16H WEIGHTED ERRORS)
  108 FORMAT(1H0,62X,6HERRORS/(1X,13F10.2))
  113 FORMAT(2X,I12,11F10.4)
 1000 FORMAT(1H1,26X,20A4,13X,A10/)
 1001 FORMAT(90X,20HWEIGHTED ERROR SUM =,E12.4)
 1002 FORMAT(55H0DATA WILL NOT BE PLOTTED BECAUSE THE ERROR SUM EXCEEDS,
     -       24H THE MAXIMUM PERMISSIBLE,E10.2/
     -       27H0INPUT TIME HISTORY FOLLOWS)
 1003 FORMAT(15H VARIABLE BIAS ,4E12.4)
 1004 FORMAT(8H0DEGREES,7X,4A12)
 2000 FORMAT(1H0,10X,12HFINAL VALUES,5X,6HMACH =,F6.3,5X,7HALPHA =,F7.2,
     -       5X,7HPARAM =,F10.4,5X,4HCG =,F6.3)
 2001 FORMAT(A4,1X,8A4,A3,4F10.3)
 2002 FORMAT(27H FINAL DIMENSIONAL MATRICES)
 2004 FORMAT(1H0,5X,4HTIME,10X,7A10/)
 2005 FORMAT(20H OUTPUT TIME HISTORY)
      RETURN
      END
```

SUBROUTINE THPLOT

Description: Subroutine THPLOT plots measured and computed time histories of observations and measured time histories of controls and extra signals.

Programing notes: The comment cards show how to decrease the run time in some instances at the cost of some storage. At present, two time histories at a time are read from the disk and plotted. Dimensions may be increased as indicated to permit more than two to be handled simultaneously, resulting in fewer disk accesses. With reasonably efficient disk units, the saving is not a significant portion of the program execution time. The limitation of 1000 points per maneuver arises from the dimensioning of X,XX,XXX and TIME as 1002. (The extra two locations are used for scaling information.) Program size may be reduced or the permissible maneuver length increased by changing this value. The special treatment of the title (plotting groups of four characters in a DO loop instead of using only one call to SYMBOL) is needed for compatibility with machines that use different word lengths.

Subroutine listing:

```
      SUBROUTINE THPLOT(FIRST)
C
C     PLOTS TIME HISTORIES
C
      COMMON /BUF/ BUFFER,YO,THGT
      COMMON /COM/ NCASE,MZ,NPTS,NPTT,SPS,PRINT,LONG,LATR,PLOTEM,ND1,
     -     D1TOL,D1RLX,NAPR,WFAC,WMAPR,ERRSUM,LAST,RATIO
      COMMON /TOPLOT/ XMAX,XMIN,DCMAX,DCMIN,TIMESC,NC
      COMMON /HEADNG/ LABELS,TITLE,JULIAN
      COMMON /LINCOM/ HGT
      DIMENSION DCMAX(8),DCMIN(8),XMAX(7),XMIN(7),NPTS(15),TITLE(20),
     -     BUFFER(1024),TIME(1002),XXX(1002,2),X(1002,1),XX(1002,1),
     -     Z(7),DC(8),ZZ(7),LABELS(15),MBCD(30)
      LOGICAL LONG,FIRST,LAST
      EQUIVALENCE (X(1,1),XXX(1,1)),(XX(1,1),XXX(1,2))
      DATA             MBCD/3HDEG,3HD/S,3HF/S,3HDEG,3HG'S,4HD/S2,3HG'S,
     -     5*3HDEG,2HFT,1H ,3HPSF,3HDEG,2*3HD/S,3HDEG,3HG'S,2*4HD/S2,
     -     5*3HDEG,4HFT/S,1H ,3HPSF/
      NCH=1
C****************** FOR A DIRECT DECREASE IN RUN TIME AT THE COST OF
C                   STORAGE, NCH MAY BE INCREASED (UP TO 7). THEN THE
C                    FOLLOWING DIMENSIONS AND EQUIVALENCE MUST BE
C                   CHANGED.
C                   DIMENSION X(1002,NCH),XX(1002,NCH),XXX(1002,2*NCH)
C****************** EQUIVALENCE (XX(1,1),XXX(1,NCH+1))
      NBUF=1024
      TIMSC2=TIMESC*2.
      XO=5.
      HGT=.01
      NIP=0
      TSI=SPS*TIMSC2
      ITHIN=-MAX1(TSI/20.,1.)
      REWIND 8
      IF(.NOT.FIRST) GO TO 10
      CALL PLOTS(BUFFER,NBUF,13)
      CALL FACTOR(RATIO)
      YO=12.
      IF(RATIO.EQ.1.) YO=9.5
      THGT=.12/RATIO
C****************** LABELS AND TITLES
   10 Y75=YO+.375
      IF (LONG) GO TO 50
      DO 20 I=1,15
   20 MBCD(I)=MBCD(I+15)
   50 DO 200 I=1,NCASE
      CALL PLOT(XO,0.,-3)
      CALL SYMBOL(-1.5,YO,THGT,TITLE(1),270.,4)
      DO 55 J=2,20
   55 CALL SYMBOL(-1.5,999.,THGT,TITLE(J),270.,4)
      IF(NCASE.EQ.1) GO TO 57
      CALL SYMBOL(-2.,YO,THGT,8HMANEUVER,270.,8)
      YO15=YO-1.5
      CALL NUMBER(-2.,YO15,THGT,FLOAT(I),270.,-1)
   57 CALL PLTDAT(-2.5,YO)
C****************** FORM TIME VECTOR AND PLOT TIME AXIS
      NOPTS=NPTS(I)
      NP1=NOPTS+1
```

```
      NP2=NOPTS+2
      DO 60 J=1,NOPTS
   60 TIME(J)=J
      TIME(NP1)=YO*TSI+1.
      TIME(NP2)=-TSI
      TLN=FLOAT(NOPTS)/TSI
      CALL AXIS(0.,YO,4HTIME,-4,TLN,270.,0.,TIMSC2)
      XORG=.5
C ****************** PLOT STATE TIME HISTORIES
      ICHAN0=0
      NCHAN=NCH
      DO 120 K=1,7
      IF(K .EQ. 1) GO TO 90
      ICHAN0=ICHAN0+NCHAN
      IF(ICHAN0+NCHAN .LE.MZ) GO TO 70
      IF(ICHAN0 .GE.MZ) GO TO 125
      NCHAN=MZ-ICHAN0
   70 REWIND 8
      IF(I .EQ. 1) GO TO 90
      DO 80 J=1,NIP
   80 READ (8)
   90 DO 100 J=1,NOPTS
      READ (8) ZZ,Z,DC
      DO 100 L=1,NCHAN
      X(J,L)=Z(L+ICHAN0)
  100 XX(J,L)=ZZ(L+ICHAN0)
      DO 110 L=1,NCHAN
      ICHAN=ICHAN0+L
      SCAL =(XMAX(ICHAN)-XMIN(ICHAN))*.5
      XMN=XMIN(ICHAN)
      IF(SCAL.NE.0.) GO TO 105
      CALL SCALES(X(1,L),2.,NOPTS,.FALSE.)
      CALL SCALES(XX(1,L),2.,NOPTS,.FALSE.)
      SCAL=AMAX1(XX(NP2,L),X(NP2,L))
      IF(SCAL.EQ.-999.) GO TO 110
      XMN=X(NP1,L)
      IF(XX(NP2,L).GT.X(NP2,L)) XMN=XX(NP1,L)
  105 CALL SYMBOL(XORG+1.,Y75,.125,LABELS(ICHAN),0,4)
      CALL AXIS(XORG,YO,MBCD(ICHAN),4,2.,0.,XMN,SCAL)
      X(NP1,L)=XMN-XORG*SCAL
      XX(NP1,L)=X(NP1,L)
       X(NP2,L)=SCAL
      XX(NP2,L)=SCAL
      CALL LINES(X(1,L),TIME,NOPTS,1, 0,1)
      CALL LINES(XX(1,L),TIME,NOPTS,ITHIN,-2,75)
      XORG=XORG+2.5
  110 CONTINUE
  120 CONTINUE
C ******************  PLOT CONTROL TIME HISTORIES
  125 NCH2=NCHAN*2
      IF(NCH2.GT.NC) NCH2=NC
      ICHAN0=-NCH2
      DO 160 K=1,4
      ICHAN0=ICHAN0+NCH2
      IF(ICHAN0.GE.NC) GO TO 170
      IF(ICHAN0+NCH2.GT.NC) NCH2=NC-ICHAN0
      REWIND 8
```

```
      IF(I .EQ. 1) GO TO 140
      DO 130 J=1,NIP
  130 READ (8)
  140 DO 150 J=1,NOPTS
      READ (8) ZZ,Z,DC
      DO 150 L=1,NCH2
  150 XXX(J,L)=DC(L+ICHAN0)
      DO 160 L=1,NCH2
      J=L+ICHAN0
      M=J+7
      SCAL =(DCMAX(J)-DCMIN(J))*.5
      DCMN=DCMIN(J)
      IF(SCAL.NE.0.) GO TO 155
      CALL SCALES(XXX(1,L),2.,NOPTS,.TRUE.)
      IF(XXX(NP2,L).EQ.-999.) GO TO 160
      IF(XXX(NP2,L).GE..4 .OR. J.EQ.7) GO TO 153
      XXX(NP2,L)=10.
      XXX(NP1,L)=-10.
  153 SCAL=XXX(NP2,L)
      DCMN=XXX(NP1,L)
  155 CALL SYMBOL (XCRG+1.,Y75,.125,LABELS(M),0,4)
      CALL AXIS(XORG,YO,MBCD(M),4,2.,0.,DCMN,SCAL)
      XXX(NP1,L)=DCMN-XORG*SCAL
      XXX(NP2,L)=SCAL
      CALL LINES(XXX(1,L),TIME,NOPTS,1, 0,1)
      XORG=XORG+2.5
  160 CONTINUE
  170 NIP=NIP+NOPTS
      XO=XORG+5.
  200 CONTINUE
      CALL PLOT(XO,0.,-3)
      RETURN
      END
```

SUBROUTINE APRPLT

Description: Subroutine APRPLT plots the variation of the derivatives with *a priori* weighting. It may be used when the *a priori* variation option is active. The information to be plotted is in the matrix STORE.

Subroutine listing:

```
      SUBROUTINE APRPLT(STORE,AA,BB,NAPR,WHOLD,WFAC,LONG,FIRST,LAST,
     -    RATIO)
C
C     PLOTS DERIVATIVES FOR APRIORI VARIATION
C
      COMMON /BUF/ BUFFER,YO,THGT
      COMMON/HEADNG/ LABELS,TITLE,JULIAN
      COMMON /LINCOM/ HGT
      LOGICAL AA(5,4),BB(5,8),LONG,FIRST,LAST
      REAL STORE(14,27),ALABLO(3,3),ALABLA(3,3),BLABLO(3,4),BLABLA(3,4),
     -    BUFFER(1024),WMAPR(14),LABELS(15),TITLE(20)
      DATA ALABLA/2HYB,2HLB,2HNB,2HYP,2HLP,2HNP,2HYR,2HLR,2HNR/,BLABLA/
     -    3HYDA,3HLDA,3HNDA,3HYDR,3HLDR,3HNDR,4HYDC1,4HLDC1,4HNDC1,
     -    4HYDC2,4HLDC2,4HNDC2/,ALABLO/2HZA,2HMA,2HXA,2HZQ,2HMQ,2HXQ,
     -    2HZU,2HMU,2HXU/,BLABLO/3HZDE,3HMDE,3HXDE,3HZDC,3HMDC,3HXDC,
     -    4HZDC1,4HMDC1,4HXDC1,4HZDC2,4HMDC2,4HXDC2/
      HGT=.07
      NBUF=1024
      JK=0
      NPT=NAPR+1
      NPT1=NPT+1
      NPT2=NPT+2
      IF(.NOT.FIRST) GO TO 5
      CALL PLOTS(BUFFER,NBUF,13)
      CALL FACTOR(RATIO)
      YO=12.
      IF(RATIO.EQ.1.) YO=9.5
      THGT=.12/RATIO
    5 CALL PLOT(0.,YO,-3)
      CALL SYMBOL(-1.5,0.,THGT,TITLE(1),270.,4)
      DO 7 J=2,20
    7 CALL SYMBOL(-1.5,999.,THGT,TITLE(J),270.,4)
      CALL PLTDAT(-4.,.5)
      WMAPR(1)=-1.
      DO 10 I=1,NAPR
   10 WMAPR(I+1)=WMAPR(I)-1.
      WMAPR(NPT1)=0.
      WMAPR(NPT2)=1.
      CALL NUMBER(-.5,-1.,.1,0.,270.,0)
      Y=-.75
      IF(NAPR.LT.2) GO TO 220
      NAPR1=NAPR-1
      W=WHOLD
      DO 210 I=1,NAPR1
      Y=Y-1.
      CALL NUMBER(-.5,Y,.1,W,270.,3)
  210 W=W*WFAC
  220 CONTINUE
      CALL SYMBOL(-1.,Y/2.,.125,5HWMAPR,270.,5)
      DO 200 I=1,3
      DO 100 J=1,4
      IF(BB(I,J)) GO TO 100
      JK=JK+1
      CALL SCALES(STORE(1,JK),3.,NPT,.FALSE.)
      DER=BLABLA(I,J)
      IF(LONG) DER=BLABLO(I,J)
      CALL AXIS(0.,0.,DER, 4,3.,0.,STORE(NPT1,JK),STORE(NPT2,JK))
```

```
      CALL LINES(STORE(1,JK),WMAPR,NPT,1,1,1)
      CALL PLOT(3.5,0.,-3)
  100 CONTINUE
      DO 200 J=1,3
      IF(AA(I,J)) GO TO 200
      JK=JK+1
      CALL SCALES(STORE(1,JK),3.,NPT,.FALSE.)
      DER=ALABLA(I,J)
      IF(LONG) DER=ALABLO(I,J)
      CALL AXIS(0.,0.,DER, 4,3.,0.,STORE(NPT1,JK),STORE(NPT2,JK))
      CALL LINES(STORE(1,JK),WMAPR,NPT,1,1,1)
      CALL PLOT(3.5,0.,-3)
  200 CONTINUE
      WMAPR(NPT)=WMAPR(NPT1)
      WMAPR(NPT1)=WMAPR(NPT2)
      NPT2=NPT1
      NPT1=NPT
      NPT=NAPR
      JK=JK+1
      CALL SCALES(STORE(1,JK),3.,NPT,.FALSE.)
      CALL AXIS(0.,0.,5HERROR,5,3.,0.,STORE(NPT1,JK),STORE(NPT2,JK))
      CALL LINES(STORE(1,JK),WMAPR,NPT,1,1,1)
      CALL PLOT(5.,-12.,-3)
      RETURN
      END
```

SUBROUTINE MATLD

Description: Subroutine MATLD reads matrices from cards and identifies the matrices.

Programing notes: ABC contains the names of the matrices that may be read in. The program compares the name read with elements of ABC to determine which matrix is being input. The characters END are taken as an indication that this is the last case; any other word not identifiable as a valid matrix name signals the end of a case, implying more cases to follow. The values of ILD and ABC indicate the status of the matrix input.

Subroutine listing:

```
      SUBROUTINE MATLD(MATRX,ABC,ILD)
C
C     LOADS IN MATRICES - DETERMINES WHICH MATRIX IS BEING READ
C          PASSES STATUS INFCRMATION BACK TO NREDIT
C
      REAL MATRX(8,8),ABC(12)
      DATA END/3HEND/
      ILD=-999
      READ (1,1000) MATRX(8,3),II,JJ
      IF(MATRX(8,3).EQ.END) RETURN
      DO 10 I=1,12
      IF(MATRX(8,3).NE.ABC(I)) GO TO 10
      ABC(I)=-99999.
      ILD=I
      GO TO 20
   10 CONTINUE
      ILD=999
      RETURN
   20 MATRX(8,1)=II
      IF(JJ.NE.0) GO TO 25
C     DIAGONAL MATRIX
      ILD=-ILD
      MATRX(8,2)=MATRX(8,1)
      CALL AZOT(MATRX)
      READ (1,1001) (MATRX(I,I),I=1,II)
      RETURN
C     FULL MATRIX
   25 MATRX(8,2)=JJ
      DO 30 I=1,II
   30 READ (1,1001) (MATRX(I,J),J=1,JJ)
      RETURN
 1000 FORMAT(A4,4X,I2,I10)
 1001 FORMAT(8F10.4)
      END
```

APPENDIX A — Continued

SUBROUTINE MAK

Description: Subroutine MAK moves an input matrix from its temporary location in MATRX to its proper location in X. Subroutines MATLD and EDIT have determined what the proper location is for each matrix.

Subroutine listing:

```
      SUBROUTINE MAK(X,MATRX,MAX)
      REAL X(MAX,1),MATRX(8,8)
      CALL ASPIT(MATRX)
      X(MAX,3)=MATRX(8,3)
      X(MAX,1)=MATRX(8,1)
      X(MAX,2)=MATRX(8,2)
      II=MATRX(8,1)
      JJ=MATRX(8,2)
      DO 10 I=1,II
      DO 10 J=1,JJ
   10 X(I,J)=MATRX(I,J)
      RETURN
      END
```

SUBROUTINE DERIV

Description: Subroutine DERIV prints dimensional and nondimensional derivatives with labels. Arrays E and EE contain the characters " " or "*" to indicate, when printed, that a particular derivative is either varying or fixed, respectively.

Subroutine listing:

```
      SUBROUTINE DERIV(LONG)
C     PRINT DIMENSIONAL AND NON-DIMENSIONAL DERIVATIVES
      COMMON /HEADNG/ LABELS,TITLE,JULIAN
      COMMON /MATRIX/ A,B,AA,BB,AP,BF,D1,RI
      COMMON /DIMENS/ C,CC,E,EE,WQS,THETN
      DIMENSION C(3,3),CC(3,5),A(5,4),B(5,8),AP(4,4),AA(5,4),BB(5,8),
     -     BP(4,8),AN(3,4),BN(3,5),E(3,3),EE(3,5),D1(8,7)
      REAL RI(5,4),LABELS(15),TITLE(20),LAB(3),LONLAB(3),LATLAB(3)
      LOGICAL LONG
      DATA F/1H /,G/1HC/,LATLAB/1HY,1HL,1HN/,LONLAB/1HN,1HM,1HA/
      DO 10 I=1,3
      LAB(I)=LATLAB(I)
      DO 5 J=1,4
    5 AN(I,J)=A(I,J)
      DO 10 J=1,5
   10 BN(I,J)=B(I,J)
      IF(.NOT.LONG) GO TO 20
      DO 15 I=1,3
      LAB(I)=LONLAB(I)
      AN(1,I)=-AN(1,I)
   15 AN(3,I)=-AN(3,I)
      DO 17 I=1,5
      BN(1,I)=-BN(1,I)
   17 BN(3,I)=-BN(3,I)
C     WRITE DIMENSIONAL DERIVATIVES
   20 WRITE(3,107)
      WRITE(3,106)(LABELS(I),I=1,3),(LABELS(J),J=8,11)
      WRITE(3,103)
     -  (F,LAB(I),(AN(I,J),E(I,J),J=1,3),(BN(I,J),EE(I,J),J=1,5),I=1,3)
C     NON-DIMENSIONALIZE
      DO 29 I = 1,3
      DO 25 J=1,5
   25 BN(I,J)=BN(I,J)*CC(I,J)
      DO 29 J=1,3
   29 AN(I,J)=AN(I,J)*C(I,J)
      IF(.NOT.LONG) AN(1,2)=0.
      WRITE(3,101)
      WRITE(3,106)(LABELS(I),I=1,3),(LABELS(J),J=8,11)
      WRITE(3,103)
     -  (G,LAB(I),(AN(I,J),E(I,J),J=1,3),(BN(I,J),EE(I,J),J=1,5),I=1,3)
      WRITE(3,108)
  101 FORMAT(48H0NON-DIMENSIONAL DERIVATIVES / DEG (ROTARY /RAD))
  103 FORMAT((1X,2A1,8(F14.6,A1,1X)))
  106 FORMAT(7(11X,A5),11X,7HDELTA-O)
  107 FORMAT(39H0DIMENSIONAL DERIVATIVES / SEC / SEC**2)
  108 FORMAT(/40X,50H( * : INDICATES DERIVATIVE HELD FIXED DURING MATCH)
      RETURN
      END
```

SUBROUTINE CRAMER

Description: Subroutine CRAMER computes confidence levels based on Cramèr-Rao bounds.

Programing notes: The comment cards trace the steps of the subroutine. Note the manipulation of the SUM matrix required to store the second gradient (Hessian) with the *a priori* terms included, while also using the second gradient without the *a priori* terms for the confidence level computation.

Subroutine listing:

```
      SUBROUTINE CRAMER(SUM,APRD,MU,MZ,ERRSUM)
C
C     COMPUTES CRAMER RAO BOUNDS (CONFIDENCE LEVELS)
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /MATRIX/ A,B,AA,BB,AP,BP,D1,RI
      COMMON /ROUTH/ PUNCH ,PARAM,MACH,ALP,CG,AC,BC
      DIMENSION A(5,4),B(5,8),AA(5,4),BB(5,8),AP(4,4),BP(4,8),D1(8,7),
     -   SUM(35,35),AC(5,4),BC(5,8),APRD(35),RI(5,4)
      LOGICAL AA,BB,FUNCH
      DATA ACL/2HAC/,BCL/2HBC/
      AC(5,1)=3.
      AC(5,2)=3.
      BC(5,1)=3.
      BC(5,2)=5.
      AC(5,3)=ACL
      BC(5,3)=BCL
      JKMM1=SUM(MAX,1)
      JK2=JKMM1-1
C******************** SUBTRACT OUT APRIORI CONTRIBUTION TO HESSIAN
C******************** STORE COMPLETE HESSIAN TEMPORARILY IN
C******************** APRIORI LOCATIONS (UPPER TRIANGULAR) SINCE LAST
C******************** USE HAS BEEN MADE OF IT.
      TEMP=SUM(JKMM1,JKMM1)
      SUM(JKMM1,JKMM1)=SUM(JKMM1,JKMM1)-APRD(JKMM1)
      APRD(JKMM1)=TEMP
      DO 10 I=1,JK2
      TEMP=SUM(I,I)
      SUM(I,I)=SUM(I,I)-APRD(I)
      APRD(I)=TEMP
      IP1=I+1
      DO 10 J=IP1,JKMM1
      TEMP=SUM(J,I)
      SUM(J,I)=SUM(J,I)-SUM(I,J)
   10 SUM(I,J)=TEMP
C******************** OBTAIN DIAGONAL ELEMENTS OF INVERSE
      CALL DIAGIN(SUM)
C******************** COMPUTE BOUNDS
      WTS = 0.0
      DO 30029 I = 1,M7
      IF (D1(I,I).NE.0.0) WTS = WTS + 1.0
30029 CONTINUE
      COEFF = ERRSUM / WTS
      L=0
      DO 71 I=1,3
      DO 60 J=1,MU
      BC(I,J)=0.
      IF(BB(I,J)          ) GO TO 60
      L=L+1
      BC(I,J)=SQRT(ABS(SUM(L,L))*COEFF)
   60 CONTINUE
      DO 70 J=1,3
      AC(I,J)=0.
      IF(AA(I,J)          ) GO TO 70
      L=L+1
      AC(I,J)=SQRT(ABS(SUM(L,L))*COEFF)
   70 CONTINUE
```

```
      IF(.NOT.AA(I,4) ) L=L+1
   71 CONTINUE
C****************** RESTORE COMPLETE HESSIAN TO LOWER TRIANGULAR PART
      SUM(JKMM1,JKMM1)=APRO(JKMM1)
      DO 80 I=1,JK2
      SUM(I,I)=APRO(I)
      IP1=I+1
      DO 80 J=IP1,JKMM1
   80 SUM(J,I)=SUM(I,J)
      RETURN
      END
```

SUBROUTINE AEAT

Description: Subroutine AEAT computes $e^{A\Delta t}$ and $\int_0^{\Delta t} e^{A\tau} d\tau$ using the Taylor series expansion.

Programing notes: The computational method used when NEAT $\neq$ 0 is described in the NAMELIST option NEAT (item (26), p. 15). The two matrices desired are returned as PHI and APHI. A2 and A3 are temporary scratch storage.

Subroutine listing:

```
      SUBROUTINE AEAT(A,TT,PHI,APHI,A2,A3,NEAT)
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION A(1),PHI(1),A2(1),APHI(1),A3(1)
              MAX2 = MAX * 2
      II=A(MAX)
      PHI(MAX)=A(MAX)
      PHI(MAX2)=A(MAX)
      T=TT/(2.**NEAT)
      CALL AZOT(PHI)
      CALL AMAKE(APHI,PHI)
      MI=-MAX
      DO 1 I = 1,II
      MI=MI+MAX
        PHI(MI + I) = 1.
    1 CONTINUE
      CALL AMAKE(A2,PHI)
      G = 1.0
      DO 2 I=1,10
      BB = I
      G = G*T/BB
      CALL AADD(1.,APHI,G,A2,APHI)
      CALL AMULT(A,A2,A3)
      CALL AMAKE(A2,A3)
      CALL AADD(1.,PHI,G,A2,PHI)
    2 CONTINUE
      IF(NEAT.EQ.0) RETURN
      DO 20 I=1,NEAT
      CALL AMAKE(A2,PHI)
      CALL AMULT(A2,A2,PHI)
      MI=-MAX
      DO 10 J=1,II
      MI=MI+MAX
   10 A2(MI+J)=A2(MI+J)+1.
      CALL AMULT(A2,APHI,A3)
      CALL AMAKE(APHI,A3)
   20 CONTINUE
      RETURN
      END
```

SUBROUTINE AMULT

Description: Subroutine AMULT computes C = A*B. The quantity C cannot be the same matrix as either A or B.

Subroutine listing:

```
      SUBROUTINE AMULT(A,B,C)
      COMMON /ALLDIM/ MAX,MIX
      REAL A(1),B(1),C(1)
      MAX2=MAX*2
      MIX2=MIX*2
      II=A(MAX)
      C(MAX)=A(MAX)
      JJ=A(MAX2)
      KK=B(MIX2)
      C(MAX2)=B(MIX2)
      JE=(JJ-1)*MAX
      KE=(KK-1)*MAX
      DO 20 I=1,II
      KEND=KE+I
      JEND=JE+I
      L=1
      DO 20 K=I,KEND,MAX
      C(K)=0.
      JB=L
      DO 10 J=I,JEND,MAX
      C(K)=A(J)*B(JB)+C(K)
   10 JB=JB+1
   20 L=L+MIX
      RETURN
      END
```

SUBROUTINE DMULT

Description: Subroutine DMULT multiplies XJI by a diagonal matrix D1.

Subroutine listing:

```
      SUBROUTINE DMULT(XJI,D1,XJID1,JKM,MZ)
      REAL XJI(35,8),XJID1(35,7),D1(8,7)
      DO 10 I=1,MZ
      DO 10 J=1,JKM
   10 XJID1(J,I)=XJI(J,I)*D1(I,I)
      RETURN
      END
```

SUBROUTINE SUMULT

Description: Subroutine SUMULT adds the term XJID1*XJI* to the SUM matrix. Only the lower triangular elements are accumulated because the result must always be symmetrical.

Subroutine listing:

```
      SUBROUTINE SUMULT(XJI,XJID1,SUM,JKM,MZ)
      REAL XJI(35,8),XJID1(35,7),SUM(35,35)
      DO 10 I=1,JKM
      DO 10 J=1,I
      DO 10 K=1,MZ
   10 SUM(I,J)=SUM(I,J)+XJID1(I,K)*XJI(J,K)
      RETURN
      END
```

SUBROUTINE PLOP

Description: Subroutine PLOP punches a matrix on cards.

Subroutine listing:

```
      SUBROUTINE PLOF(X)
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION X(1)
  102 FORMAT (8F10.6)
  103 FORMAT(A4,4X,I2,I10)
      MAX2=MAX+MAX
      MAX3=MAX2+MAX
      II=X(MAX)
      JJ=X(MAX2)
      WRITE(2,103)X(MAX3),II,JJ
      KE=(JJ-1)*MAX
      DO 2 I=1,II
      KEND=I+KE
    2 WRITE(2,102)(X(K),K=I,KEND,MAX)
      RETURN
      END
```

SUBROUTINE ASPIT

Description: Subroutine ASPIT prints a matrix.

Subroutine listing:

```
      SUBROUTINE ASPIT(X)
C WRITES OUT MATRICES
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION X(1)
  100 FORMAT(1X,A4,30X,I3,4H  BY,I3)
  101 FORMAT (12X,10E12.4)
               MAX2 = MAX * 2
      MAX3=MAX2+MAX
      II=X(MAX)
      JJ=X(MAX2)
      WRITE(3,100)X(MAX3),II,JJ
      KE=(JJ-1)*MAX
      DO 1 I =1,II
      KEND=I+KE
    1 WRITE(3,101)(X(K),K=I,KEND,MAX)
      RETURN
      END
```

SUBROUTINE AADD

Description: Subroutine AADD adds scalar multiples of two matrices. $Z = g*X + h*Y$ with $g = 1$.

Subroutine listing:

```
      SUBROUTINE AADD (G,X,H,Y,Z)
C     SPECIALIZED VERSION FOR NR ASSUMES G=1.
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION X(1),Y(1),Z(1)
               MAX2 = MAX * 2
                  II = X(MAX)
                 JJ = X(MAX2)
      JEND=(JJ-1)*MAX+1
      IIM1=II-1
      DO 53 J=1,JEND,MAX
      KEND=J+IIM1
      DO  53 K=J,KEND
   53 Z(K)=X(K)+H*Y(K)
      Z(MAX)=X(MAX)
      Z(MAX2)=X(MAX2)
      RETURN
      END
```

SUBROUTINE AZOT

Description: Subroutine AZOT sets all elements of a matrix to 0.

Subroutine listing:

```
      SUBROUTINE AZOT(X)
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION X(1)
               MAX2 = MAX * 2
      IIM1=X(MAX)-1.
      JJM1=X(MAX2)-1.
      LEND=JJM1*MAX+1
      DO 1 L=1,LEND,MAX
      KEND=L+IIM1
      DO 1 K=L,KEND
    1 X(K)=0.
      RETURN
      END
```

SUBROUTINE AMAKE

Description: Subroutine AMAKE moves the matrix Y into X.

Subroutine listing:

```
      SUBROUTINE AMAKE(X,Y)
      COMMON /ALLDIM/ MAX,MIX
      DIMENSION X(1),Y(1)
              MAX2 = MAX * 2
      IIM1=Y(MAX)-1.
      JJM1=Y(MAX2)-1.
      LEND=JJM1*MAX+1
      DO 1 L=1,LEND,MAX
      KEND=L+IIM1
      DO 1 K=L,KEND
    1 X(K)=Y(K)
      X(MAX)=Y(MAX)
      X(MAX2)=Y(MAX2)
      RETURN
      END
```

SUBROUTINE INV

Description: Subroutine INV inverts a general matrix in place.

Programing notes: Gauss elimination is used here; there is no pivoting, since this subroutine will be called only for a well-conditioned, near-diagonal matrix (the R matrix). See reference 9 for a discussion of this method.

Subroutine listing:

```
      SUBROUTINE INV(A,MAX)
C     INVERTS A GENERAL MATRIX IN PLACE
C     NO PIVOTING (DIAGONAL ELEMENTS MUST BE NON-ZERO)
      DIMENSION A(MAX,1)
      N=A(MAX,1)
      DO 80 K=1,N
      BIGA=A(K,K)
      DO 50 I=1,N
      IF(I.EQ.K) GO TO 50
      A(I,K)=-A(I,K)/BIGA
   50 CONTINUE
      DO 60 I=1,N
      IF(I.EQ.K) GO TO 60
      DO 55 J=1,N
      IF (J.EQ.K) GO TO 55
      A(I,J)=A(I,J)+A(I,K)*A(K,J)
   55 CONTINUE
   60 CONTINUE
      DO 70 J=1,N
      IF(J.EQ.K) GO TO 70
      A(K,J)=A(K,J)/BIGA
   70 CONTINUE
   80 A(K,K)=1./BIGA
      RETURN
      END
```

SUBROUTINE SOLVE

Description: Subroutine SOLVE solves the system of linear equations, $Ax = b$, where A is symmetrical. It uses Cholesky's matrix decomposition. (See programing notes for subroutine REDUCE.) Only the lower triangular and diagonal elements of A are used.

Programing notes: The b vector is assumed to be stored as the N + 1 column of A, where N is the dimension of the system.

Subroutine listing:

```
      SUBROUTINE SOLVE(A,X)
C
C     SOLVES SYSTEM AX=B (A SYMMETRIC, B STORED IN N+1 COLUMN OF A)
C
      REAL A(35,1),X(35)
      CALL REDUCE (A)
      N=A(35,1)
      NM1=N-1
      NP1=N+1
C***************** MULTIPLY (L)*(B)
      DO 70 I=2,N
      X(I)=A(I,NP1)
      IM1=I-1
      DO 70 J=1,IM1
   70 X(I)=X(I)+A(I,J)*A(J,NP1)
C***************** MULTIPLY BY (DI)
      A(1,NP1)=A(1,NP1)/A(1,1)
      DO 80 I=2,N
   80 A(I,NP1)=X(I)/A(I,I)
C***************** MULTIPLY BY (L*) TO FORM (L*)*(DI)*(L)*(B)
      DO 90 I=1,NM1
      X(I)=A(I,NP1)
      IP1=I+1
      DO 90 J=IP1,N
   90 X(I)=X(I)+A(J,I)*A(J,NP1)
      X(N)=A(N,NP1)
      RETURN
      END
```

SUBROUTINE DIAGIN

Description: Subroutine DIAGIN obtains the diagonal elements of the inverse of a symmetric matrix. It uses Cholesky's decomposition of the matrix. (See subroutine REDUCE programing notes.)

Subroutine listing:

```
      SUBROUTINE DIAGIN(A)
C
C     FIND DIAGONAL ELEMENTS OF A INVERSE FOR SYMMETRIC A
C
      REAL A(35,1)
      CALL REDUCE (A)
      N=A(35,1)
      NM1=N-1
      DO 90 I=1,NM1
      A(I,I)=1./A(I,I)
      IP1=I+1
      DO 90 J=IP1,N
   90 A(I,I)=A(I,I)+A(J,I)**2/A(J,J)
      A(N,N)=1./A(N,N)
      RETURN
      END
```

SUBROUTINE REDUCE

Description: Subroutine REDUCE factors a symmetric matrix A by Cholesky's matrix decomposition.

Programing notes: The matrix is factored into $L^{-1}DL^{-1*}$, where L is the lower diagonal with unity diagonal elements, and D is diagonal. The lower diagonal, L, is returned in the lower triangular locations of A, except for the diagonal locations, which contain D.

Subroutine listing:

```
      SUBROUTINE REDUCE(A)
C
C     REDUCES SYMMETRIC MATRIX A STORED IN LOWER TRIANGULAR LOCATIONS
C     TO THE FORM (LI)*(D)*(LI*) WHERE L IS A LOWER TRIANGULAR MATRIX
C          WITH UNITY DIAGONAL TERMS, D IS A DIAGONAL MATRIX,
C          I DENOTES INVERSE AND * TRANSPOSE
C
      REAL A(35,1)
      N=A(35,1)
      NM1=N-1
      DO 20 K=1,NM1
      KP1=K+1
      KM1=K-1
      AKKI=1./A(K,K)
      DO 20 I=KP1,N
      AKKIK=A(I,K)*AKKI
      DO 10 J=I,N
   10 A(J,I)=A(J,I)-AKKIK*A(J,K)
      A(I,K)=-AKKIK
      IF(KM1.EQ.0) GO TO 20
      DO 15 J=1,KM1
   15 A(I,J)=A(I,J)-AKKIK*A(K,J)
   20 CONTINUE
C****************** L IS NOW STORED IN LOWER TRIANGULAR PART OF A
C***************** EXCEPT FOR DIAGONAL, WHICH CONTAINS D
      RETURN
      END
```

SUBROUTINE SCALES

Description: Subroutine SCALES determines scales for plotting the vector X on an axis S inches long. If the formal parameter ZERO is true, 0 must be included in the scale.

Programing notes: The minimum value on the axis is returned in location X(N + 1), and the scale in units per inch is returned in location X(N + 2). The only scales permitted are 2, 4, and 10 units per inch times a multiple of 10. A -999. is returned to indicate that all values of X are the same.

Subroutine listing:

```
      SUBROUTINE SCALES(X,S,N,ZERO)
      LOGICAL ZERO
      REAL X(1),FAC(3)
      DATA FAC/2.,4.,10./
      XMAX=X(1)
      XMIN=X(1)
      IF(.NOT.ZERO) GO TO 10
      XMAX=0.
      XMIN=0.
   10 DO 20 I=1,N
      XMAX=AMAX1(XMAX,X(I))
   20 XMIN=AMIN1(XMIN,X(I))
      A=XMAX-XMIN
      IF(A.NE.0.) GO TO 30
      SCALE=-999.
      GO TO 100
   30 B=A/S
      J=IFIX(ABS(ALOG10(B)))
      IF(B.LT.1.) J=-J-1
      FACT=10.**J
      B=B/FACT
      DO 50 I=1,3
      SCALE=FACT*FAC(I)
      AMIN=XMIN-AMOD(XMIN,SCALE)
      IF(AMIN.GT.XMIN) AMIN=AMIN-SCALE
      IF((XMAX-AMIN).LE.SCALE*S) GO TO 100
   50 CONTINUE
      SCALE=10.*FACT*FAC(1)
      AMIN=XMIN-AMOD(XMIN,SCALE)
      IF(AMIN.GT.XMIN) AMIN=AMIN-SCALE
  100 X(N+1)=AMIN
      X(N+2)=SCALE
      RETURN
      END
```

SUBROUTINE LINES

Description: Subroutine LINES plots solid or dashed lines or symbols of the X-axis versus the Y-axis.

Programing notes: The quantities X and Y are assumed to have scaling information in locations NPT + 1 and NPT + 2 as placed there by subroutine SCALES or other sources. Every ISKIP point of the data is used, and the sign of ISKIP determines whether the plot is to be made starting from the lower numbered locations in the arrays (positive sign) or the higher numbered locations (negative sign). If JSKIP = 0, a solid line is plotted; if positive, a solid line is plotted with symbols every JSKIPth point. If JSKIP = -1, only symbols are plotted. A dashed line may be plotted using JSKIP = -2. The quantity L indicates the symbol to be plotted if relevant, and HGT gives its height.

Subroutine listing:

```
      SUBROUTINE LINES(X,Y,NPT,ISKIP,JSKIP,L)
C     ISKIP=+ PLOT FORWARD,- BACKWARDS
C     JSKIP= 0 LINE CNLY,+ LINE AND SYMBOLS, - SYMBOLS ONLY OR DASHED LN
      COMMON /LINCOM/ HGT
      REAL X(1),Y(1)
      LOGICAL SYMB
      IF(ABS(HGT-.5).GE..5) HGT=.07
      XMIN=X(NPT+1)
      YMIN=Y(NPT+1)
      DX=X(NPT+2)
      DY=Y(NPT+2)
      IS=IABS(ISKIP)
      N=(NPT-1)/IS+1
      NA=1
      IF(ISKIP.LT.0) NA=IS*(N-1)+1
      JMOD=MAX0(IABS(JSKIP),1)*IS
      SYMB=.TRUE.
      IF(JSKIP.EQ.0) SYMB=.FALSE.
      IL=-2
      IF(JSKIP.LT.0) IL=-1
      CALL PLOT((X(NA)-XMIN)/DX,(Y(NA)-YMIN)/DY,3)
      DO 50 I=1,N
      IF(SYMB.AND.MOD(NA-1,JMOD).EQ.0) GO TO 30
      CALL PLOT((X(NA)-XMIN)/DX,(Y(NA)-YMIN)/DY,2)
      GO TO 50
   30 CALL SYMBOL((X(NA)-XMIN)/DX,(Y(NA)-YMIN)/DY,HGT,L,0,IL)
   50 NA=NA+ISKIP
      RETURN
      END
```

SUBROUTINE PLTDAT

Description: Subroutine PLTDAT is used to identify plots. It is machine specific for the date and time software. The subroutine may be altered to reflect the form of plot identification desired (or a null subroutine may be used).

Subroutine listing:

```
      SUBROUTINE PLTCAT(X,Y)
C     PLOTS DATE AND TIME FOR PLOT ICENTIFICATION
C     MACHINE SPECIFIC FOR DATE AND TIME SOFTWARE
      CALL SYMBOL(X,Y,.1,DATE(JULIAN),0.,10)
      CALL SYMBOL(999.,Y,.1,TIME(SECOND),0.,10)
      RETURN
      END
```

FUNCTION TIME

Description: FUNCTION TIME is a dummy function to substitute for the TIME function available on CDC 6000/7000 systems. If using such a system, FUNCTION TIME may be removed; for other systems it may be rewritten to properly access the system time, or it may be retained. It is called only from subroutine PLTDAT.

Function listing:

```
      FUNCTION TIME(ARG)
C     DUMMY SUBROUTINE IF TIME NOT AVAILABLE
      DATA BLNK/1H /
      ARG=BLNK
      TIME=BLNK
      RETURN
      END
```

FUNCTION DATE

Description: FUNCTION DATE is a dummy function to substitute for the DATE function available on CDC 6000/7000 systems. As with FUNCTION TIME, FUNCTION DATE should be removed if using such a system and should be either rewritten or retained when used on other systems. It is called from subroutine PLTDAT and EDIT.

Function listing:

```
      FUNCTION DATE(ARG)
C     DUMMY SUBROUTINE IF DATE NOT AVAILABLE
      DATA BLNK/1H /
      ARG=BLNK
      DATE=BLNK
      RETURN
      END
```

ASSEMBLER LANGUAGE SUBROUTINES

Since the program spends a large part of its time in matrix multiplication, the execution time may be reduced considerably by writing the two small matrix multiplication subroutines AMULT and SUMULT in efficient assembler language code. In the following listings these two subroutines are written in COMPASS for use on CDC systems. These particular subroutines should be usable on any 6000 or 7000 series CDC system with the FORTRAN EXTENDED compiler. (The RUN compiler has different subroutine linkage conventions.) The use of these subroutines in place of the FORTRAN routines will speed up the program by 20 percent to 25 percent. If extensive use on other systems is anticipated, it may be advisable to make assembler versions for them. Some FORTRAN optimizers may be efficient enough to negate the gain realized; the 20 percent to 25 percent improvement mentioned, however, is referenced to the highest level of optimization available with a CDC FORTRAN 4.0 compiler.

ASSEMBLY SUBROUTINE AMULT

Subroutine listing:

```
                                                   IDENT  AMULT
                                                   ENTRY  AMULT
                                                   USE    CODE
                                                   USE    /ALLDIM/
0                          1         MAX           BSS    1
1                          1         MAM           BSS    1
                                                   USE CODE
0   0400400000 +                     AMULT         EQ     AMULT+400000B
1   5140000000 C                                   SA4    MAX
              5150000001 C                         SA5    MAM
2   63240                                          SB2    X4              MAX
         63350                                     SB3    X5              MAM
              6110777776                           SB1    -1              -1
3   55211                                          SA2    A1-B1           B
         55321                                     SA3    A2-B1           C
              66421                                SB4    B2+B1           MAX-1
                   66631                           SB6    B3+B1           MAM-1
4   53414                                          SA4    X1+B4           A(MAX,1)
         53526                                     SA5    X2+B6           B(MAM,1)
              10644                                BX6    X4
                   53634                           SA6    X3+B4           =C(MAX,1)
5   26444                                          UX4    B4,X4
         22444                                     LX4    B4,X4
              63541                                SB5    X4+B1           II-1
                   26565                           UX5    B6,X5
6   22565                                          LX5    B6,X5
         63750                                     SB7    X5              JJ
              54553                                SA5    A5+B3           B(MAM,2)
                   10655                           BX6    X5
7   54662                                          SA6    A6+B2           =C(MAX,2)
         26045                                     UX0    B4,X5
              22040                                LX0    B4,X0           KK
                   66410                           SB4    B1              I=0 FOR FIRST K
10  67441                            LOOPIK        SB4    B4-B1           I=I+1
         73714                                     SX7    X1+B4
              66600                                SB6    B0              J=0
                   76600                           SX6    B0
11  53470                            LOOPJ         SA4    X7              A
         53526                                     SA5    X2+B6           B
              40445                                FX4    X4*X5           A*B
                   30664                           FX6    X6+X4           +C
12  73772                                          SX7    X7+B2           STEP A
         67661                                     SB6    B6-B1           J=J+1
              0767000011 +                         LT     B6,B7,LOOPJ
13  24606                                          NX6    X6
         53634                                     SA6    X3+B4           =C
              0745000010 +                         LT     B4,B5,LOOPIK
14  66410                                          SB4    B1              I=0
         73001                                     SX0    X0+B1           K=K+1
              73223                                SX2    X2+B3           STEP B
                   73332                           SX3    X3+B2           STEP C
15  0310000010 +                                   NZ     X0,LOOPIK
              0400300000 +                         EQ     AMULT
16                                                 END
```

ASSEMBLY SUBROUTINE SUMULT

Subroutine listing:

```
                                                   IDENT SUMULT
                                                   ENTRY SUMULT
                                                   USE   /ALLDIM/
 0                         2          MAX          BSS   2
                                                   USE   CODE
 0  0400400000 +                      SUMULT       EQ    SUMULT+400000B
 1  6110000001                                     SB1   1              1
                  5150000000 C                     SA5   MAX
 2  63250                                          SB2   X5
         10711                                     BX7   X1             XJI
                  5011000001                       SA1   A1+1           XJID1
 3  5021000001                                     SA2   A1+1           SUM
                  5042000001                       SA4   A2+1
 4  53340                                          SA3   X4
         63430                                     SB4   X3             JKM
                  54441                            SA4   A4+B1
                           53440                   SA4   X4
 5  42445                                          IX4   X4*X5
         63740                                     SB7   X4             MZ*MAX
                  66500                            SB5   B0
                           63351                   SB3   X5+B1          MAX+1
 6  73075                             LOOPIK       SX0   X7+B5          LOC(XJI(K,1))
         53525                                     SA5   X2+B5          SUM(K,I)
                  10655                            BX6   X5
                           66600                   SB6   B0             J=0
 7  53406                             LOOPJ        SA4   X0+B6          XJI(K,J)
         53516                                     SA5   X1+B6          XJI(I,J)
                  40545                            FX5   X4*X5
                           30656                   FX6   X5+X6
10  66662                                          SB6   B6+B2          J=J+1
         24606                                     NX6   X6
                  0767000007 +                     LT    B6,B7,LOOPJ
11  53625                                          SA6   X2+B5          =SUM(I,K)
         66551                                     SB5   B5+B1          K=K+1
                  0754000006 +                     LT    B5,B4,LOOPIK
12  66500                                          SB5   B0             RESTART K
         67441                                     SB4   B4-B1          LOWER K LIMIT   I=I+1
                  73111                            SX1   X1+B1          STEP LOC(XJI(I,1))
                           73223                   SX2   X2+B3          STEP SUM LOC TO DIAGONAL
13  73771                                          SX7   X7+B1
         0704000006 +                              LT    B0,B4,LOOPIK
14  0400000000 +                                   EQ    SUMULT
15                                                 END
```

SEGMENTATION

Although the MMLE program does not require OVERLAY or SEGMENTATION to fit on most large computers, it is usually desirable to segment the program to decrease the load on the system. The following SEGMENTATION directives are used on the CDC OPERATING SYSTEM SCOPE 3.4 to reduce the loaded program size from $74{,}000_8$ words to $52{,}000_8$ words (including all buffers and system routines for input/output). The cost in execution time is negligible. The structure illustrated by these directives may be used as a guide for implementing the MMLE program on other systems.

```
PLTTREE   TREE    LINES-(THPLOT,APRPLT)
DATTREE   TREE    MATLD-(EDIT,DATA)
DOTREE    TREE    AEAT-(AGIRL,OUTPUT)
          TREE    MMLE-(PLTTREE,ASPIT-(DATTREE,DOTREE))
LINES     GLOBAL  LINCOM
ASPIT     GLOBAL  TOGIRL,INFO,TODATA,ROUTH,DIMENS
          GLOBAL  ALLDIM,BUF,MATRIX,COM,TOPLOT,HEADNG
          END
```

APPENDIX B

SAMPLE CHECK CASE FOR MMLE PROGRAM

This appendix presents a sample check case for the MMLE program. This listing is intended to aid the user in checking out the MMLE program; therefore, many of the available options have not been used.

INPUT CARDS

```
AIRCRAFT A CHECK CASE
 $INPUT CARD=T,Q=520.,V=4665., $END
 0 0 0   0   0 0 5875
A          4          4
-0.038     0.111      -1.0       0.0069
-16.79     -0.241     0.4        0.0
1.55       -0.00284   -0.042     0.0
            1.
B          4          5
            .0148
 12.76      20.08
 .3577      -2.445

D1         7
 2160.     6.5        4860.      135.       22.65     2.7        198.
ENDCASE
 0 0 0  25      .7200     2.0000     .2808     .7999     .0150    -5.0024    -.2006
    -.7000      .0800     0.0000    0.0000
 0 0 0  50      .6800     2.0000     .2808     .7999     .0150    -5.0023    -.3495
    -.8000      .0800     0.0000    0.0000
 0 0 0  75      .6500     1.9996     .2922     .9002     .0150    -4.7500    -.5503
    -.8700      .1400     0.0000    0.0000
 0 0 0 100      .6300     1.5015     .2808     .9002     .0150    -4.2519    -.8020
    -.9200      .2200     0.0000    0.0000
 0 0 0 125      .6200     1.5012     .2521     .9002     .0150    -3.7474   -1.0487
    -.9750      .3500     0.0000    0.0000
 0 0 0 150      .6200     1.5015     .2292     .9002     .0150    -2.4985   -1.3984
   -1.0200      .6000     0.0000    0.0000
 0 0 0 175      .6200     1.5012     .2005     .9999     .0200    -1.2491   -1.7017
   -1.0650      .8500     0.0000    0.0000
 0 0 0 200      .6300     1.7476     .1490     .9999     .0230     1.0026   -2.0513
   -1.1100     1.0800     0.0000    0.0000
 0 0 0 225      .6500     1.9999     .0515     .9999     .0250     3.5008   -2.4522
   -1.1300     1.3300     0.0000    0.0000
 0 0 0 250      .7000     2.2979    0.0000     .9999     .0300     5.7451   -2.8991
   -1.1650     1.5500     0.0000    0.0000
 0 0 0 275      .7200     2.4984    -.0516     .9999     .0350     8.2507   -3.3007
   -1.1900     1.7400     0.0000    0.0000
 0 0 0 300      .7500     3.0022    -.1490    1.3001     .0420    11.9998   -3.7018
   -1.2200     1.9400     0.0000    0.0000
 0 0 0 325      .7800     3.5011    -.2292    1.3998     .0440    15.0034   -4.1483
   -1.2450     2.1000     0.0000    0.0000
 0 0 0 350      .8000     3.7989    -.3495    1.5001     .0440    16.5007   -4.5322
   -1.2700     2.2400     0.0000    0.0000
 0 0 0 375      .8100     4.2001    -.4527    1.5001     .0470    18.5029   -4.8476
   -1.2900     2.3700     0.0000    0.0000
 0 0 0 400      .8300     4.4980    -.5672    1.6004     .0540    19.4973   -5.0995
   -1.3100     2.4700     0.0000    0.0000
 0 0 0 425      .8800     5.5005    -.6989    1.7001     .0540    20.0497   -5.4205
   -1.3400     2.5400     0.0000    0.0000
 0 0 0 450      .9200     5.9966    -.8194    1.8004     .0540    20.0510   -5.3002
   -1.3550     2.6000     0.0000    0.0000
 0 0 0 475      .9000     6.4995    -.9514    2.0003     .0540    20.0494   -5.4492
   -1.3650     2.6400     0.0000    0.0000
 0 0 0 500     1.0000     7.5012   -1.0487    2.2003     .0520    20.0510   -5.3002
   -1.3700     2.6500     0.0000    0.0000
 0 0 0 525     1.0300     7.9976   -1.2494    2.3000     .0520    19.9953   -5.1512
   -1.3800     2.6550     0.0000    0.0000
 0 0 0 550     1.1200     8.4949   -1.3808    2.5000     .0490    18.9998   -5.0024
   -1.3850     2.6400     0.0000    0.0000
 0 0 0 575     1.1800     9.0035   -1.5014    2.7000     .0440    17.9991   -4.8015
   -1.390      2.6000     0.0000    0.0000
```

0 0 0 600	1.2300	9.5004	-1.6500	3.0002	.0400	15.9962	-4.5497
-1.4000	2.5600	0.0000	0.0000				
0 0 0 625	1.2800	9.9975	-1.7820	3.5005	.0300	13.5010	-4.2514
-1.4050	2.4800	0.0000	0.0000				
0 0 0 650	1.3500	10.1966	-1.9193	3.7004	.0230	9.9978	-3.9022
-1.4100	2.3800	0.0000	0.0000				
0 0 0 675	1.4000	10.4995	-1.9999	4.0001	.0200	6.2493	-3.4495
-1.4150	2.2600	0.0000	0.0000				
0 0 0 700	1.4500	10.8021	-2.0971	4.3004	-.0010	1.5014	-3.0486
-1.4150	2.1200	0.0000	0.0000				
0 0 0 725	1.5500	11.2024	-2.1776	4.5003	-.0090	-3.0025	-2.5500
-1.4150	1.9700	0.0000	0.0000				
0 0 0 750	1.6300	11.0014	-2.2173	4.7003	-.0160	-7.9986	-2.0513
-1.4150	1.7600	0.0000	0.0000				
0 0 0 775	1.7200	10.8002	-2.2805	5.0006	-.0330	-13.4995	-1.5013
-1.4150	1.5500	0.0000	0.0000				
0 0 0 800	1.8000	10.4960	-2.3208	5.3002	-.0640	-18.5019	-.9510
-1.4200	1.3400	0.0000	0.0000				
0 0 0 825	1.8800	10.1975	-2.3720	5.5002	-.0710	-23.7513	-.4524
-1.4230	1.0800	0.0000	0.0000				
0 0 0 850	1.9800	9.4984	-2.3777	5.9019	-.0880	-29.0006	.0516
-1.4250	.8400	0.0000	0.0000				
0 0 0 875	2.0200	8.4954	-2.3893	5.9993	-.1140	-33.9995	.4011
-1.4250	.6400	0.0000	0.0000				
0 0 0 900	2.1000	7.4985	-2.3781	5.9993	-.1360	-38.4998	.7506
-1.4250	.4800	0.0000	0.0000				
0 0 0 925	2.2000	6.4958	-2.3662	6.1999	-.1460	-41.4997	1.0027
-1.4250	.4100	0.0000	0.0000				
0 0 0 950	2.2300	5.2031	-2.3610	6.3030	-.1620	-44.4998	1.2492
-1.4250	.3400	0.0000	0.0000				
0 0 0 975	2.3200	3.9993	-2.3492	6.4978	-.1770	-46.4981	1.3984
-1.4230	.3000	0.0000	0.0000				
0 0 1 0	2.3900	2.8022	-2.2975	6.4978	-.1890	-48.4971	1.4782
-1.4200	.2600	0.0000	0.0000				
0 0 1 25	2.4300	1.5013	-2.2520	6.4978	-.1890	-50.4962	1.5529
-1.4150	.2500	0.0000	0.0000				
0 0 1 50	2.5200	.2980	-2.2002	6.4978	-.1960	-51.5039	1.6273
-1.4100	.2400	0.0000	0.0000				
0 0 1 75	2.6000	-1.0029	-2.1490	6.3030	-.2100	-53.0045	1.7018
-1.4000	.2200	0.0000	0.0000				
0 0 1 100	2.6300	-2.4985	-2.0969	6.3030	-.2200	-53.7489	1.7476
-1.4000	.2000	0.0000	0.0000				
0 0 1 125	2.6800	-3.7014	-1.9998	6.3030	-.2250	-54.4991	1.7991
-1.3900	.1900	0.0000	0.0000				
0 0 1 150	2.7200	-5.0022	-1.9481	6.3030	-.2290	-55.0028	1.8509
-1.3650	.1800	0.0000	0.0000				
0 0 1 175	2.7800	-6.4956	-1.9023	6.3030	-.2390	-55.5006	1.9193
-1.3400	.1750	0.0000	0.0000				
0 0 1 200	2.8000	-7.6984	-1.8510	6.1999	-.2340	-55.7462	1.9884
-1.3000	.1700	0.0000	0.0000				
0 0 1 225	2.8300	-9.0271	-1.7818	5.9993	-.2440	-55.9981	2.0112
-1.2600	.1650	0.0000	0.0000				
0 0 1 250	2.8500	-10.3046	-1.7475	5.7988	-.2460	-55.9980	2.0283
-1.2150	.1600	0.0000	0.0000				
0 0 1 275	2.8900	-11.5018	-1.7020	5.7002	-.2460	-55.7456	2.0514
-1.1600	.1550	0.0000	0.0000				
0 0 1 300	2.9000	-13.0020	-1.5989	5.0006	-.2480	-55.4990	2.0683
-1.1100	.1500	0.0000	0.0000				
0 0 1 325	2.9500	-15.0014	-1.5528	4.5003	-.2480	-55.0003	2.0801
-1.0500	.1500	0.0000	0.0000				
0 0 1 350	2.9700	-16.3016	-1.5011	4.3004	-.2510	-54.4962	2.0684
-.9900	.1500	0.0000	0.0000				
0 0 1 375	2.9700	-17.6987	-1.3979	3.5005	-.2480	-53.9977	2.0625
-.9250	.1500	0.0000	0.0000				
0 0 1 400	2.9700	-19.1998	-1.3692	3.0002	-.2480	-53.7457	2.0[illegible]12
-.8650	.1500	0.0000	0.0000				

0 0 1 425	2.9500	-20.7978	-1.3006	2.5000	-.2480	-53.0010	2.0284
-.7900	.1500	0.0000	0.0000				
0 0 1 450	2.9300	-21.9947	-1.2322	2.0003	-.2480	-52.4968	2.0224
-.7300	.1500	0.0000	0.0000				
0 0 1 475	2.9200	-23.5012	-1.1805	1.5001	-.2460	-51.5000	1.9997
-.6700	.1500	0.0000	0.0000				
0 0 1 500	2.9000	-24.8013	-1.1173	.7999	-.2440	-49.9992	1.9481
-.6000	.1500	0.0000	0.0000				
0 0 1 525	2.8500	-26.0040	-1.0483	.3000	-.2440	-48.4983	1.9023
-.5400	.1500	0.0000	0.0000				
0 0 1 550	2.8000	-27.4991	-1.0025	-.5001	-.2390	-46.0004	1.8509
-.4700	.1500	0.0000	0.0000				
0 0 1 575	2.7500	-28.9999	-.9509	-.9999	-.2340	-42.4995	1.8220
-.4200	.1500	0.0000	0.0000				
0 0 1 600	2.6300	-30.5014	-.9681	-2.0003	-.2220	-39.5030	1.7819
-.3600	.1500	0.0000	0.0000				
0 0 1 625	2.5700	-31.8009	-.8482	-2.8003	-.2200	-36.2490	1.7018
-.3200	.1550	0.0000	0.0000				
0 0 1 650	2.4800	-33.1986	-.8023	-3.8001	-.2100	-33.4993	1.6271
-.2750	.1600	0.0000	0.0000				
0 0 1 675	2.3900	-34.4992	-.7792	-4.5003	-.2010	-30.0042	1.5817
-.2400	.1600	0.0000	0.0000				
0 0 1 700	2.3000	-35.4954	-.6992	-5.3002	-.1980	-26.9969	1.4785
-.2200	.1600	0.0000	0.0000				
0 0 1 725	2.2200	-36.4976	-.6478	-5.9993	-.1910	-24.0007	1.4098
-.2000	.1600	0.0000	0.0000				
0 0 1 750	2.1000	-37.7981	-.6190	-7.0021	-.1810	-21.9961	1.3178
-.1800	.1650	0.0000	0.0000				
0 0 1 775	2.0200	-39.0011	-.5786	-7.9991	-.1690	-19.0000	1.2319
-.1600	.1700	0.0000	0.0000				
0 0 1 800	1.9300	-39.5050	-.5503	-9.0018	-.1570	-16.5025	1.1519
-.1400	.1700	0.0000	0.0000				
0 0 1 825	1.8200	-40.5015	-.4984	-9.9988	-.1480	-13.7530	1.0485
-.1300	.1700	0.0000	0.0000				
0 0 1 850	1.7300	-40.9997	-.4587	-11.0016	-.1360	-11.2499	.9513
-.1200	.1700	0.0000	0.0000				
0 0 1 875	1.6300	-41.5036	-.4298	-11.9986	-.1290	-8.7470	.8311
-.1000	.1700	0.0000	0.0000				
0 0 1 900	1.5300	-41.5035	-.4183	-12.8038	-.1240	-6.2495	.7505
-.0900	.1700	0.0000	0.0000				
0 0 1 925	1.4300	-41.5032	-.3897	-13.4999	-.1050	-3.5012	.6477
-.0800	.1700	0.0000	0.0000				
0 0 1 950	1.3000	-40.9988	-.3784	-14.5026	-.0880	-1.2494	.5214
-.0600	.1700	0.0000	0.0000				
0 0 1 975	1.2200	-40.7982	-.3726	-15.8033	-.0810	1.0025	.4011
-.0500	.1700	0.0000	0.0000				
0 0 2 0	1.1200	-40.5000	-.3494	-16.5024	-.0640	3.5008	.2807
-.0400	.1700	0.0000	0.0000				
0 0 2 25	1.0100	-40.2993	-.3378	-17.2014	-.0520	6.0015	.1776
-.0250	.1700	0.0000	0.0000				
0 0 2 50	.9200	-39.8005	-.3208	-18.0036	-.0380	8.0001	.0516
-.0100	.1700	0.0000	0.0000				
0 0 2 75	.8000	-39.5023	-.2982	-19.0007	-.0300	9.9986	-.0802
0.0000	.1700	0.0000	0.0000				
0 0 2 100	.7000	-38.7975	-.2977	-20.0034	-.0180	11.9970	-.2177
.0100	.1700	0.0000	0.0000				
0 0 2 125	.6000	-38.0012	-.3211	-20.7999	-.0040	14.2533	-.3496
.0200	.1700	0.0000	0.0000				
0 0 2 150	.4700	-36.9985	-.3324	-21.4989	.0060	16.2523	-.4298
.0350	.1700	0.0000	0.0000				
0 0 2 175	.4000	-36.0016	-.3494	-22.5017	.0180	18.5027	-.5787
.0450	.1700	0.0000	0.0000				
0 0 2 200	.3000	-35.1997	-.3780	-23.5044	.0400	20.5013	-.6991
.0500	.1700	0.0000	0.0000				
0 0 2 225	.2200	-34.0022	-.3897	-24.0030	.0440	22.5001	-.8[illegible]79
.0600	.1700	0.0000	0.0000				

0 0 2 250	.1300	-33.3033	-.4127	-25.0000	.0520	24.4984	-.9509
.0650	.1700	0.0000	0.0000				
0 0 2 275	.0300	-32.0027	-.4300	-26.0027	.0640	25.5002	-1.0487
.0700	.1700	0.0000	0.0000				
0 0 2 300	-.0300	-30.7996	-.4526	-26.7992	.0730	27.4987	-1.1802
.0750	.1700	0.0000	0.0000				
0 0 2 325	-.1200	-29.4993	-.4986	-27.5040	.0860	28.9987	-1.3005
.0800	.1700	0.0000	0.0000				
0 0 2 350	-.1800	-28.5025	-.5213	-28.5010	.0980	30.9977	-1.3809
.0800	.1700	0.0000	0.0000				
0 0 2 375	-.2500	-27.5002	-.5670	-29.2001	.1070	31.9993	-1.5011
.0900	.1700	0.0000	0.0000				
0 0 2 400	-.3500	-26.3028	-.5901	-30.0023	.1190	33.4997	-1.5870
.0900	.1700	0.0000	0.0000				
0 0 2 425	-.4000	-25.5006	-.6016	-30.8045	.1290	34.2494	-1.6787
.0900	.1700	0.0000	0.0000				
0 0 2 450	-.4500	-23.9998	-.6474	-31.5035	.1360	35.4978	-1.7477
.0950	.1700	0.0000	0.0000				
0 0 2 475	-.5500	-22.9974	-.6817	-32.0020	.1410	36.2475	-1.8451
.1000	.1700	0.0000	0.0000				
0 0 2 500	-.5800	-21.6970	-.7219	-32.8042	.1480	36.9974	-1.9196
.1000	.1700	0.0000	0.0000				
0 0 2 525	-.6300	-20.5000	-.7794	-33.5033	.1560	37.4952	-1.9828
.1000	.1700	0.0000	0.0000				
0 0 2 550	-.6800	-19.6980	-.8023	-34.0018	.1600	38.4975	-2.0285
.1000	.1700	0.0000	0.0000				
0 0 2 575	-.7300	-18.4951	-.8479	-34.5003	.1650	38.7491	-2.0799
.0900	.1700	0.0000	0.0000				
0 0 2 600	-.7800	-17.0000	-.8994	-35.0045	.1700	39.0005	-2.1490
.0900	.1700	0.0000	0.0000				
0 0 2 625	-.8000	-15.9975	-.9227	-35.0045	.1700	39.5045	-2.1773
.0900	.1700	0.0000	0.0000				
0 0 2 650	-.8300	-14.5025	-.9800	-36.0016	.1730	40.0028	-2.2004
.0900	.1700	0.0000	0.0000				
0 0 2 675	-.8500	-13.5000	-1.0085	-36.3053	.1730	40.2489	-2.2289
.0900	.1700	0.0000	0.0000				
0 0 2 700	-.8800	-12.5033	-1.0484	-36.5001	.1820	40.5008	-2.2522
.0850	.1700	0.0000	0.0000				
0 0 2 725	-.9000	-11.5008	-1.0774	-36.7006	.1820	40.5009	-2.2407
.0800	.1700	0.0000	0.0000				
0 0 2 750	-.9000	-10.2008	-1.1515	-37.0043	.1850	40.7531	-2.2291
.0700	.1700	0.0000	0.0000				
0 0 2 775	-.9000	-9.5022	-1.1917	-37.2049	.1850	40.9995	-2.2289
.0600	.1700	0.0000	0.0000				
0 0 2 800	-.9000	-8.0011	-1.2203	-37.5028	.1850	40.9995	-2.2289
.0500	.1700	0.0000	0.0000				
0 0 2 825	-.9000	-6.9989	-1.2780	-37.6003	.1850	40.9997	-2.2174
.0350	.1700	0.0000	0.0000				
0 0 2 850	-.8800	-5.9966	-1.3180	-37.7034	.1850	40.9997	-2.2117
.0200	.1700	0.0000	0.0000				
0 0 2 875	-.8500	-5.0024	-1.3808	-37.8008	.1850	40.9998	-2.2002
.0100	.1700	0.0000	0.0000				
0 0 2 900	-.8200	-3.5013	-1.3980	-37.8008	.1850	41.0001	-2.1773
-.0100	.1700	0.0000	0.0000				
0 0 2 925	-.8000	-2.8021	-1.4324	-37.9039	.1800	41.0004	-2.1486
-.0300	.1700	0.0000	0.0000				
0 0 2 950	-.7800	-1.5014	-1.4498	-37.9039	.1800	40.7543	-2.1202
-.0400	.1700	0.0000	0.0000				
0 0 2 975	-.7700	-.8024	-1.5185	-37.9039	.1800	40.4969	-2.0802
-.0500	.1700	0.0000	0.0000				
0 0 3 0	-.7500	.2980	-1.5527	-37.8008	.1750	39.9986	-2.0514
-.0600	.1700	0.0000	0.0000				
0 0 3 25	-.7000	1.0025	-1.5814	-37.8003	.1750	39.5005	-2.0111
-.0700	.1700	0.0000	0.0000				
0 0 3 50	-.6500	1.9997	-1.6213	-37.8038	.1730	38.4980	-1.9826
-.0750	.1700	0.0000	0.0000				

0 0 3 75	-.6300	3.0028	-1.6504	-37.7034	.1730	37.4959	-1.9198
-.0800	.1700	0.0000	0.0000				
0 0 3 100	-.6000	3.9996	-1.6788	-37.7034	.1700	36.4994	-1.8678
-.0850	.1700	0.0000	0.0000				
0 0 3 125	-.5500	4.6987	-1.7304	-37.5028	.1650	35.4972	-1.8107
-.0900	.1700	0.0000	0.0000				
0 0 3 150	-.5000	5.5007	-1.7476	-37.3023	.1600	33.4977	-1.7704
-.0950	.1700	0.0000	0.0000				
0 0 3 175	-.4300	6.2958	-1.7819	-37.0043	.1600	32.0029	-1.7017
-.1000	.1700	0.0000	0.0000				
0 0 3 200	-.3800	7.0004	-1.7992	-36.8038	.1480	30.5024	-1.6214
-.1000	.1700	0.0000	0.0000				
0 0 3 225	-.3300	7.7967	-1.8220	-36.7006	.1460	28.7493	-1.5815
-.1050	.1700	0.0000	0.0000				
0 0 3 250	-.2500	8.4955	-1.8507	-36.5001	.1410	27.0024	-1.5015
-.1100	.1700	0.0000	0.0000				
0 0 3 275	-.2000	9.2974	-1.8793	-36.3053	.1390	25.4962	-1.4212
-.1100	.1700	0.0000	0.0000				
0 0 3 300	-.1200	9.9963	-1.9023	-36.2021	.1270	23.9956	-1.3524
-.1150	.1700	0.0000	0.0000				
0 0 3 325	-.0500	10.5002	-1.9312	-36.0016	.1220	22.5008	-1.2780
-.1200	.1700	0.0000	0.0000				
0 0 3 350	0.0000	10.8037	-1.9482	-35.8010	.1170	21.0003	-1.1977
-.1230	.1700	0.0000	0.0000				
0 0 3 375	.0300	11.5026	-1.9711	-35.6005	.1100	19.4998	-1.1175
-.1240	.1700	0.0000	0.0000				
0 0 3 400	.1000	12.0011	-1.9770	-35.3025	.0980	17.9995	-1.0201
-.1250	.1700	0.0000	0.0000				
0 0 3 425	.1800	12.3047	-1.9826	-35.0045	.0950	16.2525	-.9509
-.1230	.1700	0.0000	0.0000				
0 0 3 450	.2500	12.7000	-1.9885	-34.5003	.0830	14.4999	-.8709
-.1200	.1700	0.0000	0.0000				
0 0 3 475	.3200	13.0038	-1.9883	-34.2998	.0760	13.4980	-.7794
-.1150	.1700	0.0000	0.0000				
0 0 3 500	.4000	13.5023	-1.9828	-34.0018	.0710	11.9977	-.6819
-.1100	.1700	0.0000	0.0000				
0 0 3 525	.4300	14.0009	-1.9824	-33.9044	.0640	10.4972	-.6016
-.1000	.1700	0.0000	0.0000				
0 0 3 550	.5300	14.3047	-1.9713	-33.8013	.0570	9.0027	-.4985
-.0900	.1700	0.0000	0.0000				
0 0 3 575	.6000	14.4021	-1.9712	-33.5033	.0490	7.5024	-.4011
-.0800	.1700	0.0000	0.0000				
0 0 3 600	.6500	14.5053	-1.9712	-33.0048	.0420	6.2541	-.3209
-.0700	.1700	0.0000	0.0000				
0 0 3 625	.7500	14.6028	-1.9596	-32.5005	.0400	5.0021	-.2006
-.0600	.1700	0.0000	0.0000				
0 0 3 650	.8300	14.6028	-1.9596	-31.9046	.0280	3.2486	-.0974
-.0400	.1700	0.0000	0.0000				
0 0 3 675	.9000	14.6946	-1.9480	-31.8015	.0200	1.7477	0.0000
-.0250	.1700	0.0000	0.0000				
0 0 3 700	.9800	14.5973	-1.9423	-31.5035	.0030	.2521	.0802
-.0100	.1700	0.0000	0.0000				
0 0 3 725	1.0300	14.5975	-1.9194	-31.0050	-.0010	-1.2490	.1777
.0100	.1700	0.0000	0.0000				
0 0 3 750	1.1200	14.5003	-1.9023	-30.5008	-.0090	-3.0027	.2693
.0250	.1700	0.0000	0.0000				
0 0 3 775	1.2000	14.3975	-1.8680	-30.3002	-.0140	-3.9997	.3782
.0500	.1700	0.0000	0.0000				
0 0 3 800	1.2700	14.3002	-1.8624	-30.0023	-.0330	-5.5008	.4526
.0700	.1700	0.0000	0.0000				
0 0 3 825	1.3500	13.9966	-1.8505	-29.8017	-.0380	-6.9960	.6016
.0900	.1700	0.0000	0.0000				
0 0 3 850	1.4000	13.6987	-1.8393	-29.5038	-.0470	-7.9980	.6821
.1200	.1700	0.0000	0.0000				
0 0 3 875	1.4700	13.5957	-1.8279	-29.3032	-.0570	-9.2459	.8020
.1400	.1700	0.0000	0.0000				

0 0 3 900	1.5200	13.4983	-1.8223	-28.9995	-.0620	-11.0041	.8994
.1700	.1700	0.0000	0.0000				
0 0 3 925	1.6000	13.0000	-1.7992	-28.5010	-.0710	-11.9997	1.0315
.2100	.1700	0.0000	0.0000				
0 0 3 950	1.6300	12.5017	-1.7818	-28.0025	-.0810	-13.4998	1.1518
.2300	.1700	0.0000	0.0000				
0 0 3 975	1.7000	12.3015	-1.7476	-27.8019	-.0860	-14.5015	1.2491
.2700	.1700	0.0000	0.0000				
0 0 4 0	1.7800	11.9983	-1.7019	-27.7045	-.1020	-15.9961	1.3522
.3000	.1700	0.0000	0.0000				
0 0 4 25	1.8300	11.5003	-1.6502	-27.5040	-.1070	-17.0029	1.5368
.3000	.1700	0.0000	0.0000				
0 0 4 50	1.8800	11.0023	-1.5984	-26.9997	-.1140	-17.9992	1.5816
.3500	.1700	0.0000	0.0000				
0 0 4 75	1.9300	10.8021	-1.5699	-26.5012	-.1190	-19.4998	1.6504
.3800	.1700	0.0000	0.0000				
0 0 4 100	1.9800	10.4991	-1.5014	-26.3007	-.1340	-20.5013	1.7706
.4000	.1700	0.0000	0.0000				
0 0 4 125	2.0100	9.5019	-1.5068	-26.2033	-.1340	-21.4976	1.8506
.4250	.1700	0.0000	0.0000				
0 0 4 150	2.0200	9.0046	-1.3983	-26.0027	-.1360	-22.4989	1.9828
.4500	.1700	0.0000	0.0000				
0 0 4 175	2.0500	8.4951	-1.3521	-25.8996	-.1430	-23.0025	2.0512
.4720	.1700	0.0000	0.0000				
0 0 4 200	2.0800	7.9974	-1.2723	-25.5042	-.1550	-23.5000	2.1488
.4900	.1700	0.0000	0.0000				
0 0 4 225	2.1000	7.4996	-1.1977	-24.7994	-.1550	-23.6997	2.2288
.5100	.1700	0.0000	0.0000				
0 0 4 250	2.1500	6.801[illegible]	-1.1518	-24.5015	-.1570	-23.8023	2.2804
.5300	.1700	0.0000	0.0000				
0 0 4 275	2.1700	6.4982	-1.0718	-24.3009	-.1650	-23.8987	2.3777
.5500	.1700	0.0000	0.0000				
0 0 4 300	2.1800	6.0004	-1.0028	-24.2035	-.1720	-23.9956	2.4182
.5700	.1700	0.0000	0.0000				
0 0 4 325	2.2100	5.0024	-.9222	-24.0030	-.1740	-23.9951	2.4698
.5800	.1700	0.0000	0.0000				
0 0 4 350	2.2200	4.4978	-.8481	-23.8998	-.1740	-23.8971	2.5209
.6000	.1700	0.0000	0.0000				
0 0 4 375	2.2300	3.9994	-.7791	-23.8024	-.1790	-23.7480	2.5325
.6100	.1700	0.0000	0.0000				
0 0 4 400	2.2400	3.5012	-.6993	-23.8024	-.1810	-23.7018	2.5727
.6220	.1700	0.0000	0.0000				
0 0 4 425	2.2500	3.0026	-.6017	-23.8024	-.1840	-23.5014	2.5499
.6400	.1700	0.0000	0.0000				
0 0 4 450	2.2700	2.2977	-.5501	-23.8024	-.1810	-22.9975	2.5210
.6500	.1700	0.0000	0.0000				
0 0 4 475	2.2800	1.7991	-.4527	-23.8024	-.1810	-22.7456	2.4983
.6600	.1700	0.0000	0.0000				
0 0 4 500	2.2900	1.1976	-.3782	-23.8024	-.1860	-22.4996	2.4527
.6700	.1700	0.0000	0.0000				
0 0 4 525	2.3000	.8021	-.2808	-23.8024	-.1860	-21.9958	2.4180
.6750	.1700	0.0000	0.0000				
0 0 4 550	2.3200	.2980	-.2005	-24.0030	-.1860	-21.4977	2.3778
.6900	.1700	0.0000	0.0000				
0 0 4 575	2.3000	0.0000	-.1318	-24.0030	-.1840	-20.5009	2.3493
.7000	.1700	0.0000	0.0000				
0 0 4 600	2.3000	-.4985	-.0688	-24.1004	-.1840	-19.7509	2.2806
.7050	.1700	0.0000	0.0000				
0 0 4 625	2.3000	-1.0026	.0172	-24.2035	-.1810	-19.0011	2.2003
.7100	.1700	0.0000	0.0000				
0 0 4 650	2.3000	-1.5014	.0516	-24.3009	-.1810	-17.9991	2.1317
.7200	.1700	0.0000	0.0000				
0 0 4 675	2.2800	-1.9997	.1203	-24.5015	-.1790	-17.5014	2.0513
.7220	.1700	0.0000	0.0000				
0 0 4 700	2.2700	-2.4980	.2005	-24.7020	-.1720	-16.7514	1.9826
.7240	.1700	0.0000	0.0000				

0 0 4 725	2.2500	-3.0025	.2292	-24.7994	-.1720	-15.9959	1.9023
.7300	.1700	0.0000	0.0000				
0 0 4 750	2.2000	-3.5011	.2808	-25.0000	-.1670	-14.7478	1.7990
.7350	.1750	0.0000	0.0000				
0 0 4 775	2.1500	-3.7989	.3495	-25.3037	-.1670	-14.2501	1.7192
.7400	.1750	0.0000	0.0000				
0 0 4 800	2.1200	-4.2975	.4011	-25.5042	-.1570	-13.5005	1.6217
.7450	.1750	0.0000	0.0000				
0 0 4 825	2.0700	-4.4983	.4298	-25.6016	-.1550	-12.5040	1.5698
.7500	.1750	0.0000	0.0000				
0 0 4 850	2.0300	-5.0020	.4813	-25.6990	-.1480	-12.0010	1.4498
.7500	.1750	0.0000	0.0000				
0 0 4 875	1.9800	-5.5006	.5271	-25.8022	-.1410	-11.1995	1.3811
.7500	.1750	0.0000	0.0000				
0 0 4 900	1.9500	-5.7987	.5673	-25.8996	-.1380	-9.9970	1.3006
.7500	.1750	0.0000	0.0000				
0 0 4 925	1.9000	-5.9989	.6016	-26.0027	-.1340	-9.0004	1.2492
.7500	.1750	0.0000	0.0000				
0 0 4 950	1.8500	-6.2967	.6188	-26.2033	-.1290	-7.9982	1.1978
.7550	.1750	0.0000	0.0000				
0 0 4 975	1.8300	-6.3996	.6472	-26.3007	-.1240	-7.0013	1.1803
.7600	.1750	0.0000	0.0000				
0 0 5 0	1.7500	-6.4966	.6821	-26.5012	-.1140	-6.2509	1.1516
.7630	.1750	0.0000	0.0000				
0 0 5 25	1.7000	-6.5993	.7222	-26.7992	-.1120	-5.5008	1.1001
.7650	.1750	0.0000	0.0000				
0 0 5 50	1.6500	-6.6963	.7679	-26.9023	-.1070	-4.2518	1.0770
.7680	.1750	0.0000	0.0000				
0 0 5 75	1.6000	-6.7990	.8022	-27.2003	-.1000	-3.0024	1.0487
.7700	.1750	0.0000	0.0000				
0 0 5 100	1.5500	-6.7989	.8194	-27.5040	-.0950	-1.5012	1.0315
.7700	.1750	0.0000	0.0000				
0 0 5 125	1.5200	-6.6956	.8309	-27.7045	-.0860	-.4985	1.0030
.7720	.1750	0.0000	0.0000				
0 0 5 150	1.4300	-6.6033	.8826	-27.8019	-.0810	1.0030	.9800
.7720	.1750	0.0000	0.0000				
0 0 5 175	1.4000	-6.5000	.8999	-28.0025	-.0760	2.4986	.9228
.7730	.1750	0.0000	0.0000				
0 0 5 200	1.3500	-6.2989	.9510	-28.0025	-.0670	3.9995	.8827
.7750	.1800	0.0000	0.0000				
0 0 5 225	1.3000	-6.0006	.9799	-28.2030	-.0620	5.9971	.8309
.7750	.1800	0.0000	0.0000				
0 0 5 250	1.2300	-5.7998	1.0030	-28.3004	-.0570	7.4983	.8194
.7800	.1800	0.0000	0.0000				
0 0 5 275	1.2000	-5.4949	1.0083	-28.4036	-.0570	9.3204	.8022
.7850	.1800	0.0000	0.0000				
0 0 5 300	1.1500	-5.2030	1.0315	-28.5010	-.0450	10.4950	.7908
.7880	.1800	0.0000	0.0000				
0 0 5 325	1.0800	-4.8017	1.0485	-28.7016	-.0350	11.4976	.7795
.7900	.1800	0.0000	0.0000				
0 0 5 350	1.0300	-3.9993	1.1172	-28.8047	-.0350	12.9987	.7508
.7900	.1800	0.0000	0.0000				
0 0 5 375	1.0000	-3.7989	1.1518	-28.9021	-.0280	14.5052	.6992
.7950	.1800	0.0000	0.0000				
0 0 5 400	.9800	-3.3006	1.1802	-28.9021	-.0230	15.5023	.6988
.8000	.1800	0.0000	0.0000				
0 0 5 425	.9200	-2.8019	1.1978	-28.9995	-.0210	16.5049	.6818
.8000	.1800	0.0000	0.0000				
0 0 5 450	.8800	-2.0000	1.2208	-28.9995	-.0180	18.0003	.6589
.8050	.1800	0.0000	0.0000				
0 0 5 475	.8300	-1.7019	1.2319	-29.1027	-.0140	18.7506	.6303
.8100	.1800	0.0000	0.0000				
0 0 5 500	.8000	-1.0026	1.2491	-28.9995	-.0060	20.2518	.6188
.8150	.1800	0.0000	0.0000				
0 0 5 525	.7500	-.4985	1.2780	-28.9021	-.0010	21.0023	.6016
.8170	.1800	0.0000	0.0000				

```
0 0 5 550      .7200      .2006     1.3009   -28.8047       .0010     21.9992       .5789
     .8200     .1800     0.0000     0.0000
0 0 5 575      .6800      .8024     1.3524   -28.7016       .0080     23.0017       .5498
     .8200     .1800     0.0000     0.0000
0 0 5 600      .6500     1.5011     1.3695   -28.6041       .0180     24.2503       .4986
     .8230     .1800     0.0000     0.0000
0 0 5 625      .6000     1.9998     1.3808   -28.5010       .0230     24.5020       .4524
     .8250     .1800     0.0000     0.0000
0 0 5 650      .5700     2.4985     1.3984   -28.4036       .0280     25.4985       .4010
     .8260     .1800     0.0000     0.0000
0 0 5 675      .5500     3.5010     1.4209   -28.3004       .0280     26.0022       .3498
     .8200     .1800     0.0000     0.0000
0 0 5 700      .5000     3.9996     1.4328   -28.3004       .0350     26.5002       .2981
     .8300     .1800     0.0000     0.0000
0 0 5 725      .4500     4.4980     1.4727   -28.2030       .0370     27.4968       .2522
     .8350     .1800     0.0000     0.0000
0 0 5 750      .4300     5.3003     1.4784   -28.0025       .0420     27.7478       .1490
     .8370     .1800     0.0000     0.0000
0 0 5 775      .4000     5.9985     1.5013   -27.8994       .0440     28.0051       .0974
     .8400     .1800     0.0000     0.0000
0 0 5 800      .3500     6.4976     1.5527   -27.8019       .0520     28.5028       .0172
     .8400     .1800     0.0000     0.0000
0 0 5 825      .3300     7.3000     1.5699   -27.7045       .0520     28.7023      -.0802
     .8400     .1800     0.0000     0.0000
0 0 5 850      .3000     7.9993     1.5814   -27.6014       .0520     28.7474      -.1490
     .8450     .1800     0.0000     0.0000
0 0 5 875      .2700     8.4978     1.5818   -27.5040       .0590     28.9987      -.2292
     .8500     .1800     0.0000     0.0000
AIRCRAFT B CHECK CASE
 $INPUT GROSWT=  2470.   ,IX=    275.   ,IY=  1902.   ,IZ=   2228.   ,IXZ=    11.6,
 Q=  39.0   ,V= 415.2   ,PUNCH=T   ,TIMESC= .5   ,BOTH=T,
 XALF=  0.00   ,XAN=  -.01   ,ZAX=    .53,
 ZMAX(3)=1000.,
 CARD=T,
 WMAPR= .10E+01   ,ALPHA=  7.86   ,MACH= .429   ,CG= .260   ,PARAM=     5.0000,
 LONG=T,  S=  85.   ,SPAN= 16.05   ,CBAR=  5.98   ,SPS= 50.,   $END
113638750 113645840
A        4         4
   -.42035    1.00000   -0.00000     .00221
  -3.79430    -.36321    0.00000    0.00000
  15.66803    0.00000   -0.00000  -32.15869
   0.00000     .99155    0.00000    0.00000
B        4         5
   -.06489   -0.00000   -0.00000   -0.00000     .07346
  -6.28073    0.00000    0.00000    0.00000     .18165
   8.35392   -0.00000   -0.00000   -0.00000   -2.39365
          1.
D1       5
  100000.0    70000.0       -0.0   400000.0    10000.0       -0.0       -0.0
APRA      4         4
  .500E+05-0.        -0.         -0.
  .300E+00  .100E+04-0.          -0.
0.         -0.       -0.         -0.
0.         -0.       -0.         -0.
APRB      4         8
  .100E+05-0.        -0.         -0.         -0.         -0.         -0.         -0.
  .100E+01-0.        -0.         -0.         -0.         -0.         -0.         -0.
0.         -0.       -0.         -0.         -0.         -0.         -0.         -0.
0.         -0.       -0.         -0.         -0.         -0.         -0.         -0.
END
113638 765     8.5753    -1.9595   413.5412     4.3927      .7507      0.0000      .0006
   -2.9244      .0309     -.0501     4.3839     2.054045599.9089      .4274     38.4406
113638 785     8.5616    -2.0726   413.6227     4.3253      .7578      0.0000     -.0005
   -2.3376      .0318     -.0486     4.3850     2.112545599.9089      .4274     38.4406
113638 805     8.5408    -2.2248   413.6921     4.3085      .7605      0.0000     -.0015
   -1.7390      .0322     -.0468     4.3858     2.196045599.9089      .4274     38.4406
```

113638 825	8.5509	-2.3516	413.7093	4.[illegible]89	.7521	0.0000	.0001
-1.5414	.0331	-.0456	4.3869	2 [illegible]3545599.9089		.4274	38.4406
113638 845	8.5879	-2.5260	413.7088	4.3038	.7402	0.0000	.0027
-1.9137	.0319	-.0437	4.3847	2.306645599.9089		.4274	38.4406
113638 865	8.6012	-2.5961	413.7083	4.2496	.7307	0.0000	.0053
-2.6130	.0314	-.0411	4.3825	2.380245599.9089		.4274	38.4406
113638 885	8.5797	-2.6251	413.7084	4.1654	.7241	0.0000	.0044
-3.3808	.0302	-.0386	4.3781	2.464545599.9089		.4274	38.4406
113638 905	8.5756	-2.5501	413.7084	4.0980	.7197	0.0000	.0016
-4.1495	.0281	-.0343	4.3781	2.504545599.9089		.4274	38.4406
113638 925	8.5627	-2.4277	413.7084	4.0813	.7094	0.0000	.0030
-4.9065	.0262	-.0314	4.3793	2.534945599.9089		.4274	38.4406
113638 945	8.4809	-2.1846	413.7084	4.0555	.6899	0.0000	.0072
-5.6091	.0253	-.0288	4.3831	2.607945599.9089		.4274	38.4406
113638 965	8.4024	-1.9271	413.7084	3.9824	.6769	0.0000	.0063
-6.0750	.0241	-.0256	4.3869	2.692645599.9089		.4274	38.4406
113638 985	8.3974	-1.6396	413.7084	3.8979	.6845	0.0000	.0004
-6.0882	.0226	-.0223	4.3906	2.732745599.9089		.4274	38.4406
113639 5	8.3924	-1.3778	413.6970	3.8580	.6937	0.0000	-.0042
-5.6172	.0212	-.0194	4.3935	2.763045599.9089		.4274	38.4406
113639 25	8.3589	-1.1780	413.5372	3.8540	.7016	0.0000	-.0028
-4.8719	.0215	-.0178	4.3968	2.836045599.6841		.4269	38.3552
113639 45	8.3762	-1.0928	413.1609	3.8549	.7085	0.0000	-.0006
-4.0660	.0214	-.0154	4.4030	2.920845583.6748		.4262	38.2710
113639 65	8.4073	-1.0380	412.6949	3.8551	.7216	0.0000	.0001
-3.2368	.0213	-.0131	4.4120	2.960945583.5624		.4260	38.2283
113639 85	8.4205	-1.0744	412.3642	3.8550	.7233	0.0000	-.0011
-2.3875	.0198	-.0101	4.4225	2.964945583.4500		.4258	38.1855
113639 105	8.4568	-1.2403	412.2143	3.8550	.7297	0.0000	-.0023
-1.5454	.0186	-.0075	4.4328	2.969645583.4500		.4258	38.1855
113639 125	8.4908	-1.4808	412.1725	3.8550	.7473	0.0000	-.0057
-.8791	.0164	-.0051	4.4407	3.023945583.4500		.4258	38.1855
113639 145	8.4271	-1.7332	412.1700	3.8289	.7544	0.0000	-.0060
-.6036	.0154	-.0036	4.4463	3.108545583.4500		.4258	38.1855
113639 165	8.3779	-2.0156	412.1710	3.7553	.7504	0.0000	-.0009
-.7918	.0129	-.0024	4.4493	3.176245583.4500		.4258	38.1855
113639 185	8.4097	-2.2631	412.1710	3.6708	.7553	0.0000	.0064
-1.3128	.0115	-.0017	4.4527	3.193045583.4500		.4258	38.1855
113639 205	8.4246	-2.4380	412.1710	3.6310	.7624	0.0000	.0098
-2.0049	.0094	-.0012	4.4544	3.192645583.4500		.4258	38.1855
113639 225	8.3743	-2.5167	412.1710	3.6008	.7494	0.0000	.0089
-2.7575	.0082	-.0007	4.4577	3.192145583.4500		.4258	38.1855
113639 245	8.3433	-2.5156	412.1710	3.5281	.7272	0.0000	.0067
-3.5236	.0058	-.0002	4.4622	3.192145583.4500		.4258	38.1855
113639 265	8.3208	-2.4164	412.1710	3.4438	.7124	0.0000	.0062
-4.2852	.0027	.0000	4.4671	3.192145583.4500		.4258	38.1855
113639 285	8.2572	-2.2232	412.1710	3.4039	.6955	0.0000	.0049
-5.0012	.0000	-.0000	4.4721	3.192145583.4500		.4258	38.1855
113639 305	8.2150	-2.0162	412.1710	3.3999	.6821	0.0000	.0037
-5.4495	-.0033	-.0005	4.4786	3.192145583.4500		.4258	38.1855
113639 325	8.2278	-1.8144	412.1443	3.4008	.6723	0.0000	.0070
-5.3935	-.0054	-.0012	4.4856	3.192145583.4500		.4258	38.1855
113639 345	8.2101	-1.6285	412.0635	3.4010	.6730	0.0000	.0084
-4.8517	-.0080	-.0024	4.4942	3.192145583.3376		.4255	38.1428
113639 365	8.1986	-1.4795	411.9219	3.3748	.6858	0.0000	.0045
-4.0525	-.0097	-.0039	4.5040	3.192145583.2252		.4253	38.1000
113639 385	8.2485	-1.4631	411.7953	3.3012	.7017	0.0000	.0014
-3.1842	-.0117	-.0059	4.5147	3.192145583.2252		.4253	38.1000
113639 405	8.2806	-1.5140	411.7223	3.2168	.7179	0.0000	.0027
-2.2934	-.0138	-.0083	4.5241	3.192145583.2252		.4253	38.1000
113639 425	8.2579	-1.6447	411.7062	3.1770	.7294	0.0000	.0013
-1.4101	-.0156	-.0110	4.5338	3.192145583.2252		.4253	38.1000
113639 445	8.2446	-1.9130	411.7067	3.1729	.7409	0.0000	-.0055
-.5447	-.0172	-.0139	4.5430	3.186545583.2252		.4253	38.1000
113639 465	8.2341	-2.2763	411.7072	3.1739	.7466	0.0000	-.0120
.2533	-.0184	-.0167	4.5499	3.132145583.2252		.4253	38.1000

113639 485	8.1615	-2.6704	411.7072	3.1479	.7476	0.0000	-.0132
.8164	-.0189	-.0183	4.5525	3.0475	45583.2252	.4253	38.1000
113639 505	8.0815	-3.0977	411.7071	3.0743	.7420	0.0000	-.0102
.9448	-.0206	-.0210	4.5539	2.9798	45583.2252	.4253	38.1000
113639 525	8.0343	-3.5353	411.7071	2.9899	.7405	0.0000	-.0052
.6279	-.0217	-.0227	4.5542	2.9630	45583.2252	.4253	38.1000
113639 545	7.9862	-3.9021	411.7035	2.9239	.7331	0.0000	-.0004
.0335	-.0237	-.0253	4.5553	2.9372	45583.2252	.4253	38.1000
113639 565	7.9403	-4.1584	411.6851	2.8463	.7157	0.0000	.0022
-.6994	-.0239	-.0259	4.5546	2.8637	45567.4531	.4251	38.1013
113639 585	7.9260	-4.3669	411.6648	2.7629	.6994	0.0000	.0027
-1.4893	-.0247	-.0274	4.5549	2.7788	45583.2252	.4253	38.1000
113639 605	7.9117	-4.5001	411.6633	2.6971	.6879	0.0000	.0005
-2.2923	-.0258	-.0285	4.5530	2.7388	45583.2252	.4253	38.1000
113639 625	7.8604	-4.5177	411.6611	2.6195	.6722	0.0000	-.0011
-3.0865	-.0277	-.0306	4.5519	2.7347	45583.2252	.4253	38.1000
113639 645	7.7962	-4.4364	411.6338	2.5305	.6545	0.0000	-.0010
-3.8947	-.0292	-.0321	4.5496	2.7094	45567.4531	.4251	38.1013
113639 665	7.7513	-4.2546	411.5866	2.4367	.6334	0.0000	.0011
-4.6789	-.0303	-.0349	4.5497	2.6356	45567.4531	.4251	38.1013
113639 685	7.6943	-3.9591	411.5608	2.3486	.6104	0.0000	.0014
-5.4106	-.0303	-.0371	4.5495	2.5507	45567.4531	.4251	38.1013
113639 705	7.6482	-3.6214	411.5579	2.2767	.5961	0.0000	.0004
-5.8926	-.0312	-.0408	4.5504	2.5106	45567.4531	.4251	38.1013
113639 725	7.6520	-3.2974	411.5585	2.2060	.5999	0.0000	-.0013
-5.8928	-.0310	-.0418	4.5509	2.5039	45567.4531	.4251	38.1013
113639 745	7.6546	-3.0145	411.5586	2.1224	.6074	0.0000	-.0014
-5.3849	-.0300	-.0437	4.5551	2.4475	45567.4531	.4251	38.1013
113639 765	7.5991	-2.7744	411.5586	2.0557	.6126	0.0000	-.0010
-4.5873	-.0286	-.0445	4.5583	2.3631	45567.4531	.4251	38.1013
113639 785	7.5399	-2.6415	411.5585	2.0389	.6193	0.0000	-.0004
-3.7049	-.0277	-.0466	4.5630	2.2954	45567.4531	.4251	38.1013
113639 805	7.5089	-2.5788	411.5585	2.0337	.6309	0.0000	-.0009
-2.8041	-.0270	-.0473	4.5636	2.2524	45567.4531	.4251	38.1013
113639 825	7.4980	-2.6031	411.5585	1.9802	.6419	0.0000	-.0027
-1.8930	-.0261	-.0497	4.5647	2.1789	45567.4531	.4251	38.1013
113639 845	7.5116	-2.7503	411.5585	1.8962	.6489	0.0000	-.0045
-.9899	-.0252	-.0511	4.5638	2.0945	45567.4531	.4251	38.1013
113639 865	7.5187	-3.0047	411.5585	1.8289	.6612	0.0000	-.0048
-.1498	-.0242	-.0522	4.5645	2.0282	45567.4531	.4251	38.1013
113639 885	7.4708	-3.3096	411.5585	1.8066	.6693	0.0000	-.0048
.4637	-.0229	-.0509	4.5624	1.9502	45567.4531	.4251	38.1013
113639 905	7.4125	-3.6380	411.5585	1.7529	.6730	0.0000	-.0064
.6720	-.0222	-.0519	4.5601	1.8664	45567.4531	.4251	38.1013
113639 925	7.3834	-3.9659	411.5585	1.6695	.6648	0.0000	-.0086
.4108	-.0223	-.0502	4.5561	1.8209	45567.4531	.4251	38.1013
113639 945	7.3499	-4.2379	411.5415	1.5761	.6581	0.0000	-.0075
-.1821	-.0223	-.0499	4.5530	1.7624	45567.4531	.4251	38.1013
113639 965	7.2839	-4.4543	411.4934	1.4859	.6421	0.0000	-.0052
-.9383	-.0215	-.0471	4.5482	1.6789	45551.6928	.4250	38.1025
113639 985	7.2205	-4.5647	411.4381	1.3964	.6286	0.0000	-.0052
-1.7436	-.0209	-.0451	4.5450	1.6114	45551.6928	.4250	38.1025
113640 5	7.1776	-4.6089	411.4121	1.3031	.6168	0.0000	-.0075
-2.5729	-.0208	-.0423	4.5402	1.5890	45551.6928	.4250	38.1025
113640 25	7.1304	-4.5240	411.4094	1.2151	.5982	0.0000	-.0077
-3.4037	-.0201	-.0400	4.5358	1.5350	45551.6928	.4250	38.1025
113640 45	7.0858	-4.3477	411.4101	1.1432	.5712	0.0000	-.0042
-4.2229	-.0190	-.0366	4.5306	1.4511	45551.6928	.4250	38.1025
113640 65	7.0637	-4.0891	411.4101	1.0726	.5524	0.0000	-.0006
-5.0267	-.0185	-.0340	4.5258	1.3834	45551.6928	.4250	38.1025
113640 85	7.0516	-3.7457	411.4101	.9890	.5461	0.0000	-.0004
-5.7853	-.0182	-.0303	4.5204	1.3666	45551.6928	.4250	38.1025
113640 105	7.0292	-3.3494	411.4101	.9167	.5448	0.0000	-.0012
-6.2541	-.0181	-.0288	4.5169	1.3614	45551.6928	.4250	38.1025
113640 125	7.0075	-2.9264	411.3834	.8459	.5425	0.0000	-.0020
-6.1758	-.0168	-.0255	4.5126	1.3075	45551.6928	.4250	38.1025

113640 145	6.9644	-2.5579	411.2815	.7624	.5468	0.0000	-.0038
-5.5759	-.0156	-.0246	4.5118	1.223145551.5805		.4247	38.0598
113640 165	6.9296	-2.2471	411.1199	.6957	.5622	0.0000	-.0062
-4.7276	-.0142	-.0222	4.5107	1.155545551.4682		.4245	38.0170
113640 185	6.9509	-2.0761	410.9929	.6790	.5797	0.0000	-.0058
-3.8206	-.0138	-.0218	4.5109	1.138745551.4682		.4245	38.0170
113640 205	7.0185	-1.9898	410.9480	.6793	.5917	0.0000	-.0056
-2.8999	-.0136	-.0200	4.5082	1.139145551.4682		.4245	38.0170
113640 225	7.0708	-1.9887	410.9448	.6798	.5991	0.0000	-.0082
-1.9766	-.0134	-.0188	4.5064	1.139645551.4682		.4245	38.0170
113640 245	7.0887	-2.0849	410.9459	.6537	.6085	0.0000	-.0110
-1.0609	-.0127	-.0161	4.5038	1.139545551.4682		.4245	38.0170
113640 265	7.0668	-2.3011	410.9784	.5803	.6219	0.0000	-.0117
-.1970	-.0118	-.0137	4.5019	1.139545551.4682		.4245	38.0170
113640 285	7.0271	-2.5909	411.1147	.4960	.6297	0.0000	-.0112
.5241	-.0108	-.0102	4.4976	1.139545551.6928		.4250	38.1025
113640 305	7.0045	-2.9428	411.3422	.4506	.6306	0.0000	-.0102
.9987	-.0103	-.0074	4.4915	1.139545551.8051		.4252	38.1453
113640 325	6.9934	-3.3233	411.5377	.3925	.6290	0.0000	-.0097
1.1520	-.0098	-.0040	4.4841	1.139545551.8051		.4252	38.1453
113640 345	6.9488	-3.7194	411.6544	.3096	.6269	0.0000	-.0100
.9748	-.0098	-.0004	4.4768	1.139545551.8051		.4252	38.1453
113640 365	6.8709	-4.0653	411.7452	.2425	.6239	0.0000	-.0125
.5325	-.0098	.0037	4.4696	1.139545551.9174		.4255	38.1880
113640 385	6.8117	-4.3533	411.8037	.1997	.6112	0.0000	-.0124
-.0810	-.0099	.0076	4.4641	1.139545551.9174		.4255	38.1880
113640 405	6.7841	-4.5533	411.7955	.1266	.5916	0.0000	-.0104
-.7934	-.0094	.0113	4.4593	1.139545551.8051		.4252	38.1453
113640 425	6.7540	-4.6728	411.7772	.0155	.5742	0.0000	-.0081
-1.5786	-.0088	.0139	4.4541	1.139545551.9174		.4255	38.1880
113640 445	6.7146	-4.7068	411.8288	-.1012	.5646	0.0000	-.0092
-2.3973	-.0083	.0160	4.4465	1.139545536.2811		.4255	38.2320
113640 465	6.6734	-4.6335	411.8957	-.1936	.5614	0.0000	-.0104
-3.2418	-.0080	.0179	4.4380	1.139545536.2811		.4255	38.2320
113640 485	6.6236	-4.4591	411.9435	-.2617	.5500	0.0000	-.0093
-4.0836	-.0079	.0201	4.4288	1.165845536.2811		.4255	38.2320
113640 505	6.5801	-4.1750	411.9628	-.3427	.5320	0.0000	-.0067
-4.9155	-.0083	.0221	4.4227	1.239645536.2811		.4255	38.2320
113640 525	6.5553	-3.7833	412.0180	-.4300	.5152	0.0000	-.0054
-5.7217	-.0086	.0235	4.4186	1.324445536.3933		.4258	38.2748
113640 545	6.5146	-3.2856	412.1033	-.4774	.5031	0.0000	-.0056
-6.5017	-.0088	.0248	4.4140	1.390745536.3933		.4258	38.2748
113640 565	6.4414	-2.7306	412.1719	-.5383	.4961	0.0000	-.0059
-7.1179	-.0091	.0256	4.4084	1.468645536.3933		.4258	38.2748
113640 585	6.3935	-2.1577	412.1889	-.6253	.4950	0.0000	-.0074
-7.3263	-.0093	.0259	4.4027	1.552545536.3933		.4258	38.2748
113640 605	6.3828	-1.6004	412.1885	-.6955	.5001	0.0000	-.0100
-7.0376	-.0093	.0251	4.3983	1.618645536.3933		.4258	38.2748
113640 625	6.4021	-1.0910	412.1880	-.7131	.5031	0.0000	-.0102
-6.4054	-.0089	.0236	4.3945	1.696645536.3933		.4258	38.2748
113640 645	6.4546	-.6705	412.1881	-.7127	.5092	0.0000	-.0079
-5.6369	-.0088	.0226	4.3945	1.806745536.3933		.4258	38.2748
113640 665	6.5216	-.3391	412.1881	-.7121	.5204	0.0000	-.0071
-4.8121	-.0081	.0192	4.3961	1.920545536.3933		.4258	38.2748
113640 685	6.5717	-.1023	412.1881	-.7122	.5336	0.0000	-.0092
-3.9468	-.0074	.0163	4.3967	2.035745536.3933		.4258	38.2748
113640 705	6.5891	.0179	412.1881	-.7122	.5467	0.0000	-.0118
-3.0331	-.0061	.0124	4.3928	2.148745536.3933		.4258	38.2748
113640 725	6.5806	.0233	412.1881	-.7122	.5626	0.0000	-.0130
-2.1098	-.0051	.0094	4.3865	2.263745536.3933		.4258	38.2748
113640 745	6.5726	-.0782	412.1881	-.7122	.5816	0.0000	-.0131
-1.2149	-.0035	.0050	4.3805	2.376745536.3933		.4258	38.2748
113640 765	6.6124	-.2655	412.1881	-.7122	.5984	0.0000	-.0128
-.3748	-.0022	.0018	4.3784	2.491845536.3933		.4258	38.2748
113640 785	6.6960	-.5360	412.1881	-.7122	.6084	0.0000	-.0125
.3738	-.0009	-.0014	4.3784	2.604845536.3933		.4258	38.2748

113640 805	6.7303	-.8618	412.1938	-.7122	.6146	0.0000	-.0113
.9201	-.0015	-.0003	4.3775	2.719945536.3933		.4258	38.2748
113640 825	6.7194	-1.2500	412.2452	-.7122	.6208	0.0000	-.0115
1.1400	-.0018	.0002	4.3717	2.833045536.5054		.4260	38.3175
113640 845	6.7228	-1.6553	412.2991	-.7395	.6255	0.0000	-.0129
.9901	-.0013	-.0012	4.3629	2.948145520.7686		.4259	38.3188
113640 865	6.7623	-2.0258	412.3576	-.8165	.6212	0.0000	-.0123
.5463	-.0001	-.0040	4.3514	3.066845536.5054		.4260	38.3175
113640 885	6.7905	-2.3265	412.3894	-.9048	.6029	0.0000	-.0095
-.0906	-.0001	-.0045	4.3397	3.210145520.8807		.4261	38.3615
113640 905	6.7796	-2.5559	412.4171	-.9464	.5861	0.0000	-.0089
-.8228	-.0007	-.0036	4.3312	3.339445536.5054		.4260	38.3175
113640 925	6.7385	-2.6859	412.3830	-.9565	.5791	0.0000	-.0110
-1.5956	-.0021	-.0009	4.3293	3.465545520.7686		.4259	38.3188
113640 945	6.6842	-2.6935	412.3332	-1.0122	.5739	0.0000	-.0119
-2.3868	-.0046	.0039	4.3282	3.592345520.7686		.4259	38.3188
113640 965	6.6612	-2.6015	412.2853	-1.0999	.5627	0.0000	-.0101
-3.2144	-.0064	.0071	4.3226	3.739145520.7686		.4259	38.3188
113640 985	6.6636	-2.4222	412.2704	-1.1704	.5470	0.0000	-.0065
-4.0647	-.0066	.0070	4.3139	3.894945520.7686		.4259	38.3188
113641 5	6.6765	-2.1588	412.2703	-1.1879	.5308	0.0000	-.0030
-4.9040	-.0056	.0047	4.3071	4.045545520.7686		.4259	38.3188
113641 25	6.6976	-1.8048	412.2708	-1.1875	.5210	0.0000	-.0020
-5.7156	-.0062	.0054	4.3022	4.196645520.7686		.4259	38.3188
113641 45	6.7189	-1.3521	412.2708	-1.1870	.5178	0.0000	-.0046
-6.5041	-.0077	.0076	4.2992	4.352045520.7686		.4259	38.3188
113641 65	6.7092	-.8386	412.2707	-1.2085	.5177	0.0000	-.0066
-7.1130	-.0097	.0106	4.2989	4.502645520.7686		.4259	38.3188
113641 85	6.7159	-.2981	412.2708	-1.2288	.5183	0.0000	-.0063
-7.3151	-.0084	.0079	4.2979	4.653745520.7686		.4259	38.3188
113641 105	6.7416	.2068	412.2708	-1.2292	.5234	0.0000	-.0064
-7.0355	-.0080	.0069	4.2964	4.809245520.7686		.4259	38.3188
113641 125	6.7871	.6758	412.2708	-1.2005	.5335	0.0000	-.0070
-6.4287	-.0086	.0074	4.2949	4.959945520.7686		.4259	38.3188
113641 145	6.8215	1.0615	412.2708	-1.1872	.5420	0.0000	-.0060
-5.6734	-.0107	.0098	4.2963	5.111245520.7686		.4259	38.3188
113641 165	6.8603	1.3800	412.2671	-1.1866	.5560	0.0000	-.0058
-4.8624	-.0104	.0089	4.2992	5.266845520.7686		.4259	38.3188
113641 185	6.9233	1.5838	412.2317	-1.1870	.5770	0.0000	-.0072
-4.0182	-.0093	.0069	4.3023	5.417545505.0436		.4257	38.3200
113641 205	7.0201	1.6708	412.1768	-1.1870	.5961	0.0000	-.0083
-3.1255	-.0077	.0047	4.3042	5.563345505.0436		.4257	38.3200
113641 225	7.1075	1.6673	412.1328	-1.1870	.6124	0.0000	-.0076
-2.2067	-.0084	.0053	4.3078	5.690745505.0436		.4257	38.3200
113641 245	7.1524	1.5621	412.1484	-1.1870	.6310	0.0000	-.0060
-1.3078	-.0102	.0069	4.3133	5.810345505.0436		.4257	38.3200
113641 265	7.1738	1.3415	412.2235	-1.1597	.6544	0.0000	-.0059
-.4664	-.0123	.0083	4.3191	5.953845505.1556		.4260	38.3628
113641 285	7.1852	1.0207	412.3097	-1.0827	.6728	0.0000	-.0071
.2674	-.0129	.0084	4.3227	6.077945505.1556		.4260	38.3628
113641 305	7.2175	.6295	412.3559	-.9944	.6821	0.0000	-.0090
.8024	-.0155	.0101	4.3242	6.176345505.1556		.4260	38.3628
113641 325	7.2808	.2203	412.4151	-.9527	.6844	0.0000	-.0091
1.0262	-.0184	.0120	4.3243	6.266645505.2676		.4262	38.4055
113641 345	7.3503	-.1925	412.4995	-.9485	.6818	0.0000	-.0079
.9075	-.0217	.0139	4.3235	6.377745505.2676		.4262	38.4055
113641 365	7.3944	-.5932	412.5679	-.9554	.6746	0.0000	-.0068
.5577	-.0266	.0167	4.3227	6.491845505.2676		.4262	38.4055
113641 385	7.4130	-.9764	412.6114	-1.0121	.6672	0.0000	-.0057
.1364	-.0323	.0199	4.3221	6.586945505.2676		.4262	38.4[illegible]55
113641 405	7.3926	-1.3062	412.6858	-1.1000	.6630	0.0000	-.0062
-.2622	-.0375	.0222	4.3229	6.681045505.3796		.4264	38.4482
113641 425	7.3631	-1.5702	412.7710	-1.1704	.6590	0.0000	-.0082
-.6366	-.0413	.0233	4.3256	6.769945505.3796		.4264	38.4482
113641 445	7.3630	-1.8010	412.8115	-1.1879	.6499	0.0000	-.0082
-1.0074	-.0459	.0245	4.3288	6.863545505.3796		.4264	38.4482

113641 465	7.3764	-1.9779	412.8156	-1.1875	.6404	0.0000	-.0052
-1.4029	-.0514	.0260	4.3314	6.954745505.3796		.4264	38.4482
113641 485	7.3535	-2.0998	412.8147	-1.1870	.6335	0.0000	-.0028
-1.8586	-.0557	.0264	4.3350	7.039745505.3796		.4264	38.4482
113641 505	7.3049	-2.1635	412.8109	-1.2143	.6256	0.0000	-.0018
-2.3828	-.0602	.0271	4.3395	7.106045505.3796		.4264	38.4482
113641 525	7.2846	-2.1609	412.7890	-1.2913	.6174	0.0000	-.0009
-2.9436	-.0658	.0280	4.3437	7.184545489.6662		.4263	38.4495
113641 545	7.2856	-2.0969	412.7732	-1.3796	.6179	0.0000	-.0031
-3.5098	-.0731	.0296	4.3453	7.269045489.6662		.4263	38.4495
113641 565	7.2840	-1.9688	412.8041	-1.4213	.6196	0.0000	-.0047
-4.0621	-.0796	.0301	4.3469	7.314945489.7781		.4265	38.4922
113641 585	7.2826	-1.7841	412.8609	-1.4256	.6085	0.0000	-.0023
-4.5779	-.0852	.0300	4.3485	7.373845489.7781		.4265	38.4922
113641 605	7.2731	-1.5453	412.9141	-1.4246	.5961	0.0000	.0004
-5.0387	-.0915	.0295	4.3526	7.458045489.7781		.4265	38.4922
113641 625	7.2743	-1.2593	412.9644	-1.4303	.5931	0.0000	-.0014
-5.4322	-.0975	.0289	4.3583	7.526045489.7781		.4265	38.4922
113641 645	7.2945	-.9367	413.0386	-1.4869	.5899	0.0000	-.0033
-5.7521	-.1026	.0277	4.3648	7.543045489.8899		.4268	38.5350
113641 665	7.3238	-.5860	413.1019	-1.5749	.5906	0.0000	-.0024
-5.9762	-.1052	.0258	4.3695	7.548345489.8899		.4268	38.5350
113641 685	7.3381	-.2209	413.1844	-1.6453	.5898	0.0000	.0006
-6.0950	-.1091	.0235	4.3734	7.602645490.0018		.4270	38.5777
113641 705	7.3679	.1440	413.2731	-1.6628	.5929	0.0000	.0013
-6.1214	-.1138	.0210	4.3770	7.687845490.0018		.4270	38.5777
113641 725	7.4081	.4916	413.3408	-1.6566	.6024	0.0000	-.0011
-6.0699	-.1214	.0184	4.3821	7.756045490.0018		.4270	38.5777
113641 745	7.4376	.8247	413.3576	-1.5994	.6140	0.0000	-.0019
-5.9239	-.1275	.0156	4.3879	7.772945490.0018		.4270	38.5777
113641 765	7.4626	1.1440	413.3438	-1.5115	.6155	0.0000	.0009
-5.6691	-.1317	.0125	4.3941	7.772645490.0018		.4270	38.5777
113641 785	7.5164	1.4166	413.3135	-1.4411	.6206	0.0000	.0018
-5.3267	-.1329	.0092	4.4000	7.772045490.0018		.4270	38.5777
113641 805	7.5690	1.6319	413.2652	-1.4236	.6372	0.0000	-.0007
-4.9299	-.1348	.0061	4.4059	7.772145474.3000		.4268	38.5790
113641 825	7.6108	1.8050	413.2279	-1.4240	.6554	0.0000	-.0021
-4.4981	-.1385	.0033	4.4109	7.772145474.3000		.4268	38.5790
113641 845	7.6597	1.9494	413.2102	-1.4245	.6673	0.0000	-.0015
-4.0433	-.1407	.0001	4.4161	7.772145474.3000		.4268	38.5790
113641 865	7.7488	2.0252	413.2079	-1.3971	.6761	0.0000	-.0016
-3.5740	-.1433	-.0028	4.4202	7.772145474.3000		.4268	38.5790
113641 885	7.8768	2.0335	413.2139	-1.3202	.6893	0.0000	-.0018
-3.0749	-.1471	-.0056	4.4239	7.772145474.3000		.4268	38.5790
113641 905	8.0000	1.9937	413.2688	-1.2319	.7006	0.0000	-.0012
-2.5602	-.1511	-.0079	4.4260	7.772145474.4118		.4271	38.6217
113641 925	8.0795	1.8834	413.3539	-1.1902	.7173	0.0000	-.0018
-2.0684	-.1544	-.0095	4.4265	7.772145474.4118		.4271	38.6217
113641 945	8.1186	1.6903	413.4277	-1.1859	.7306	0.0000	-.0024
-1.6253	-.1581	-.0109	4.4257	7.772145474.4118		.4271	38.6217
113641 965	8.1385	1.4291	413.4994	-1.1869	.7383	0.0000	-.0014
-1.2239	-.1619	-.0101	4.4246	7.772145474.5235		.4273	38.6644
113641 985	8.1499	1.1514	413.5841	-1.1870	.7452	0.0000	-.0029
-.8823	-.1642	-.0091	4.4223	7.772145474.5235		.4273	38.6644
113642 5	8.1768	.8657	413.6781	-1.1870	.7527	0.0000	-.0061
-.6458	-.1670	-.0075	4.4191	7.772145474.5235		.4273	38.6644
113642 25	8.2498	.5536	413.7695	-1.1870	.7614	0.0000	-.0075
-.5259	-.1727	-.0067	4.4169	7.772145474.6352		.4275	38.7071
113642 45	8.3543	.2099	413.8545	-1.1870	.7663	0.0000	-.0053
-.4995	-.1773	-.0066	4.4154	7.772145474.6352		.4275	38.7071
113642 65	8.4298	-.1315	413.8999	-1.1870	.7662	0.0000	-.0017
-.5424	-.1806	-.0056	4.4137	7.772145474.6352		.4275	38.7071
113642 85	8.4301	-.4597	413.9587	-1.1870	.7606	0.0000	.0021
-.6642	-.1833	-.0030	4.4104	7.772145474.7469		.4278	38.7498
113642 105	8.4094	-.7566	414.0427	-1.1870	.7552	0.0000	.0045
-.9032	-.1859	.0003	4.4065	7.772145474.7469		.4278	38.7498

113642 125	8.4327	-1.0202	414.1106	-1.1870	.7543	0.0000	.0062
-1.2670	-.1889	.0046	4.4021	7.772145474.7469		.4278	38.7498
113642 145	8.4780	-1.2382	414.1276	-1.1870	.7536	0.0000	.0071
-1.7173	-.1928	.0091	4.3981	7.777845474.7469		.4278	38.7498
113642 165	8.5037	-1.4136	414.1401	-1.1870	.7510	0.0000	.0062
-2.2184	-.1962	.0137	4.3938	7.811845474.7469		.4278	38.7498
113642 185	8.4932	-1.5163	414.1841	-1.1870	.7417	0.0000	.0021
-2.7542	-.1977	.0173	4.3896	7.877345474.8586		.4280	38.7925
113642 205	8.4739	-1.5403	414.2209	-1.2143	.7258	0.0000	-.0020
-3.3067	-.1994	.0208	4.3856	7.945245459.1683		.4279	38.7938
113642 225	8.4635	-1.4998	414.2239	-1.2913	.7102	0.0000	-.0026
-3.8601	-.2025	.0245	4.3822	7.990045459.1683		.4279	38.7938
113642 245	8.4669	-1.4259	414.2102	-1.3796	.7017	0.0000	.0005
-4.3958	-.2057	.0287	4.3792	8.002445459.1683		.4279	38.7938
113642 265	8.4733	-1.3015	414.2069	-1.4213	.7020	0.0000	.0030
-4.8840	-.2089	.0331	4.3767	8.002545459.1683		.4279	38.7938
113642 285	8.4700	-1.1238	414.2128	-1.4256	.7041	0.0000	.0046
-5.3120	-.2123	.0375	4.3743	8.002145459.1683		.4279	38.7938
113642 305	8.4743	-.8732	414.2675	-1.4246	.7003	0.0000	.0069
-5.6727	-.2136	.0416	4.3707	8.002145459.2799		.4281	38.8365
113642 325	8.4689	-.5903	414.3523	-1.4244	.7018	0.0000	.0078
-5.9532	-.2153	.0442	4.3671	8.028645459.2799		.4281	38.8365
113642 345	8.4717	-.2981	414.4202	-1.4245	.7082	0.0000	.0043
-6.1229	-.2195	.0466	4.3641	8.103245459.2799		.4281	38.8365
113642 365	8.5024	-.0091	414.4428	-1.4245	.7184	0.0000	-.0025
-6.1739	-.2237	.0494	4.3619	8.188945459.2799		.4281	38.8365
113642 385	8.5523	.2911	414.4969	-1.4245	.7200	0.0000	-.0058
-6.1194	-.2248	.0520	4.3595	8.229345459.3915		.4283	38.8792
113642 405	8.5822	.5724	414.6075	-1.4245	.7225	0.0000	-.0050
-5.9787	-.2230	.0534	4.3570	8.233445459.3915		.4283	38.8792
113642 425	8.5960	.8025	414.7459	-1.4245	.7167	0.0000	-.0004
-5.7561	-.2233	.0547	4.3546	8.232445459.5031		.4286	38.9219
113642 445	8.6294	1.0105	414.8160	-1.4245	.7149	0.0000	.0047
-5.4610	-.2247	.0562	4.3526	8.258845443.8243		.4284	38.9232
113642 465	8.6838	1.1922	414.8190	-1.4245	.7283	0.0000	.0065
-5.1137	-.2264	.0581	4.3511	8.333545459.5031		.4286	38.9219
113642 485	8.7506	1.3412	414.7854	-1.4245	.7503	0.0000	.0003
-4.7290	-.2272	.0599	4.3500	8.419245443.8243		.4284	38.9232
113642 505	8.8153	1.4179	414.7623	-1.4245	.7606	0.0000	-.0042
-4.2967	-.2261	.0602	4.3501	8.459645443.8243		.4284	38.9232
113642 525	8.8595	1.4284	414.7473	-1.3971	.7632	0.0000	-.0012
-3.8114	-.2244	.0607	4.3497	8.469445443.8243		.4284	38.9232
113642 545	8.8736	1.3996	414.7447	-1.3202	.7749	0.0000	.0014
-3.2801	-.2242	.0605	4.3489	8.523445443.8243		.4284	38.9232
113642 565	8.8811	1.3291	414.7450	-1.2319	.7905	0.0000	-.0020
-2.7438	-.2262	.0603	4.3480	8.608645443.8243		.4284	38.9232
113642 585	8.9093	1.1684	414.7507	-1.1902	.8002	0.0000	-.0052
-2.2467	-.2280	.0608	4.3468	8.677045443.8243		.4284	38.9232
113642 605	8.9563	.9046	414.8052	-1.1859	.8148	0.0000	-.0024
-1.7986	-.2285	.0639	4.3439	8.694045443.9358		.4287	38.9659
113642 625	9.0086	.5967	414.8954	-1.1869	.8382	0.0000	-.0017
-1.4014	-.2291	.0690	4.3390	8.720245443.9358		.4287	38.9659
113642 645	9.0580	.2816	415.0177	-1.1870	.8539	0.0000	-.0044
-1.0565	-.2297	.0731	4.3337	8.794445444.0473		.4289	39.0085
113642 665	9.0817	-.0565	415.1453	-1.1870	.8500	0.0000	-.0091
-.7822	-.2301	.0762	4.3297	8.880245444.0473		.4289	39.0085
113642 685	9.0864	-.4018	415.2866	-1.1870	.8453	0.0000	-.0131
-.5940	-.2293	.0791	4.3267	8.926445444.1587		.4291	39.0512
113642 705	9.0715	-.7777	415.3878	-1.1870	.8474	0.0000	-.0153
-.5046	-.2320	.0841	4.3231	8.985545444.1587		.4291	39.0512
113642 725	9.0385	-1.1860	415.4275	-1.2143	.8497	0.0000	-.0133
-.5125	-.2363	.0889	4.3193	9.070045444.1587		.4291	39.0512
113642 745	9.0044	-1.5860	415.4574	-1.2913	.8390	0.0000	-.0067
-.6304	-.2399	.0928	4.3160	9.144045444.1587		.4291	39.0512
113642 765	8.9872	-1.9502	415.5267	-1.3796	.8201	0.0000	.0010
-.8551	-.2421	.0966	4.3119	9.216145444.2702		.4294	39.0939

113642 785	8.9917	-2.2720	415.5815	-1.4213	.7939	0.0000	.0092
-1.1282	-.2443	.0998	4.3087	9.301245428.6029		.4292	39.0952
113642 805	8.9748	-2.5674	415.6207	-1.4256	.7839	0.0000	.0102
-1.3710	-.2447	.1029	4.3060	9.374945428.7142		.4294	39.1379
113642 825	8.9304	-2.8328	415.6650	-1.4519	.8027	0.0000	.0016
-1.5447	-.2451	.1061	4.3024	9.447145428.7142		.4294	39.1379
113642 845	8.8721	-3.0945	415.7207	-1.5287	.8219	0.0000	-.0048
-1.6749	-.2469	.1105	4.2966	9.532245428.7142		.4294	39.1379
113642 865	8.8340	-3.3087	415.7376	-1.6171	.8072	0.0000	-.0018
-1.7944	-.2487	.1137	4.2924	9.606045428.7142		.4294	39.1379
113642 885	8.7901	-3.4851	415.7638	-1.6646	.7868	0.0000	.0046
-1.9100	-.2507	.1174	4.2888	9.678245428.7142		.4294	39.1379
113642 905	8.7284	-3.6448	415.8371	-1.7255	.7867	0.0000	.0017
-2.0297	-.2538	.1212	4.2862	9.763445428.8256		.4297	39.1805
113642 925	8.6786	-3.7946	415.9217	-1.8125	.7915	0.0000	-.0060
-2.1759	-.2559	.1246	4.2840	9.858145428.8256		.4297	39.1805
113642 945	8.6489	-3.9164	415.9617	-1.9101	.7800	0.0000	-.0040
-2.3432	-.2573	.1262	4.2829	9.950245428.8256		.4297	39.1805
113642 965	8.6181	-4.0079	415.9658	-2.0047	.7609	0.0000	.0062
-2.5246	-.2575	.1273	4.2790	10.055745428.8256		.4297	39.1805
113642 985	8.5761	-4.0877	415.9910	-2.0926	.7456	0.0000	.0091
-2.7130	-.2598	.1299	4.2744	10.151645428.8256		.4297	39.1805
113643 6	8.5341	-4.1368	416.0647	-2.1611	.7368	0.0000	.0043
-2.9128	-.2586	.1329	4.2703	10.225545428.9369		.4299	39.2232
113643 25	8.4928	-4.1579	416.1322	-2.2424	.7215	0.0000	.0016
-3.1324	-.2619	.1373	4.2658	10.309745428.9369		.4299	39.2232
113643 45	8.4453	-4.1210	416.1295	-2.3356	.7055	0.0000	.0029
-3.3670	-.2648	.1415	4.2592	10.424445413.2812		.4298	39.2245
113643 65	8.3790	-4.0680	416.1323	-2.4339	.6983	0.0000	.0046
-3.5917	-.2689	.1457	4.2522	10.566745413.3924		.4300	39.2672
113643 86	8.2822	-3.9925	416.1894	-2.5261	.7053	0.0000	.0030
-3.7884	-.2691	.1474	4.2473	10.675045413.3924		.4300	39.2672
113643 105	8.1665	-3.8884	416.2540	-2.6015	.7111	0.0000	.0006
-3.9760	-.2695	.1484	4.2439	10.770145413.3924		.4300	39.2672
113643 126	8.0742	-3.7383	416.2715	-2.6755	.7077	0.0000	-.0011
-4.1668	-.2711	.1503	4.2414	10.885645413.3924		.4300	39.2672
113643 145	8.0266	-3.5806	416.2711	-2.7632	.6880	0.0000	-.0025
-4.3535	-.2764	.1541	4.2388	11.027945413.3924		.4300	39.2672
113643 166	7.9986	-3.4136	416.2706	-2.8390	.6713	0.0000	-.0030
-4.5233	-.2810	.1566	4.2354	11.157245413.3924		.4300	39.2672
113643 186	7.9579	-3.2287	416.2706	-2.9132	.6645	0.0000	-.0024
-4.6686	-.2848	.1584	4.2302	11.277945413.3924		.4300	39.2672
113643 206	7.9225	-3.0259	416.2968	-3.0009	.6657	0.0000	.0009
-4.7852	-.2857	.1580	4.2241	11.422645413.3924		.4300	39.2672
113643 226	7.8973	-2.8001	416.3704	-3.0709	.6566	0.0000	.0030
-4.8852	-.2850	.1562	4.2193	11.553545413.5036		.4302	39.3098
113643 246	7.8846	-2.5635	416.4811	-3.0884	.6507	0.0000	.0035
-4.9740	-.2856	.1539	4.2158	11.681245413.5036		.4302	39.3098
113643 266	7.8888	-2.3219	416.5774	-3.1154	.6526	0.0000	.0028
-5.0448	-.2878	.1524	4.2123	11.788745413.6148		.4305	39.3525
113643 286	7.8940	-2.0681	416.6176	-3.1919	.6581	0.0000	.0013
-5.0807	-.2889	.1492	4.2104	11.912145397.9706		.4303	39.3538
113643 306	7.8705	-1.8060	416.6272	-3.2863	.6616	0.0000	-.0009
-5.0882	-.2902	.1453	4.2104	12.041045397.9706		.4303	39.3538
113643 326	7.8488	-1.5385	416.6784	-3.3221	.6581	0.0000	-.0021
-5.0656	-.2911	.1399	4.2109	12.184545398.0817		.4305	39.3965
113643 346	7.8491	-1.2977	416.7592	-3.3264	.6498	0.0000	-.0008
-5.0227	-.2897	.1333	4.2115	12.313945398.0817		.4305	39.3965
113643 365	7.8505	-1.0682	416.7995	-3.3254	.6492	0.0000	.0017
-4.9533	-.2854	.1251	4.2133	12.429445398.0817		.4305	39.3965
113643 386	7.8355	-.8561	416.8037	-3.3252	.6630	0.0000	.0006
-4.8506	-.2832	.1176	4.2163	12.525145398.0817		.4305	39.3965
113643 406	7.8321	-.6442	416.8027	-3.3253	.6718	0.0000	-.0013
-4.7027	-.2821	.1102	4.2199	12.620245398.0817		.4305	39.3965
113643 426	7.8598	-.4432	416.8026	-3.3253	.6663	0.0000	-.0018
-4.5438	-.2833	.1033	4.2240	12.715945398.0817		.4305	39.3965

113643 446	7.9140	-.2701	416.7892	-3.3468	.6644	0.0000	-.0011
-4.3822	-.2851	.0967	4.2272	12.839345398.0817		.4305	39.3965
113643 466	7.9515	-.1424	416.7820	-3.3945	.6703	0.0000	-.0023
-4.2160	-.2843	.0896	4.2295	12.942345398.0817		.4305	39.3965
113643 486	7.9386	-.0362	416.8322	-3.4720	.6804	0.0000	-.0041
-4.0384	-.2819	.0827	4.2307	13.016645398.1928		.4308	39.4391
113643 506	7.9234	.0667	416.8986	-3.5316	.6909	0.0000	-.0048
-3.8601	-.2813	.0761	4.2329	13.088745382.5602		.4306	39.4404
113643 526	7.9502	.1430	416.9190	-3.5601	.6989	0.0000	-.0015
-3.6712	-.2799	.0695	4.2363	13.174445382.5602		.4306	39.4404
113643 546	7.9891	.1706	416.9123	-3.5638	.7040	0.0000	.0027
-3.4702	-.2773	.0631	4.2404	13.243045382.5602		.4306	39.4404
113643 566	8.0057	.1708	416.9461	-3.5632	.7125	0.0001	.0019
-3.2599	-.2768	.0582	4.2437	13.286945382.5602		.4306	39.4404
113643 586	8.0128	.1609	417.0141	-3.5631	.7237	0.0000	-.0023
-3.0412	-.2783	.0536	4.2460	13.362045382.6712		.4309	39.4831
113643 606	8.0121	.1356	417.0433	-3.5631	.7328	0.0000	-.0048
-2.8244	-.2801	.0488	4.2481	13.448145382.5602		.4306	39.4404
113643 626	8.0064	.0785	417.0599	-3.5631	.7392	0.0000	-.0030
-2.6166	-.2810	.0441	4.2515	13.489045382.6712		.4309	39.4831
113643 646	8.0214	-.0166	417.1065	-3.5631	.7403	0.0000	-.0017
-2.4270	-.2811	.0389	4.2562	13.493245382.6712		.4309	39.4831
113643 666	8.0563	-.1266	417.2024	-3.5631	.7385	0.0000	-.0005
-2.2538	-.2816	.0331	4.2609	13.519045382.7822		.4311	39.5257
113643 686	8.0812	-.2565	417.2909	-3.5631	.7386	0.0000	-.0014
-2.0998	-.2831	.0281	4.2636	13.594445382.7822		.4311	39.5257
113643 706	8.1004	-.4051	417.3302	-3.5631	.7412	0.0000	-.0040
-1.9635	-.2821	.0241	4.2650	13.681145382.7822		.4311	39.5257
113643 726	8.1229	-.5715	417.3341	-3.5631	.7412	0.0000	-.0055
-1.8459	-.2779	.0199	4.2676	13.722045382.7822		.4311	39.5257
113643 746	8.1375	-.7432	417.3160	-3.5631	.7361	0.0000	-.0028
-1.7540	-.2740	.0149	4.2724	13.726245382.7822		.4311	39.5257
113643 766	8.1174	-.9137	417.2676	-3.5631	.7380	0.0000	.0005
-1.6966	-.2715	.0098	4.2782	13.725245367.1611		.4309	39.5270
113643 786	8.0898	-1.0875	417.2382	-3.5631	.7477	0.0000	.0014
-1.6725	-.2721	.0055	4.2831	13.725145367.1611		.4309	39.5270
113643 806	8.0847	-1.2628	417.2853	-3.5631	.7547	0.0000	-.0005
-1.6816	-.2745	.0013	4.2868	13.725145367.2720		.4312	39.5697
113643 826	8.0918	-1.4487	417.3668	-3.5690	.7564	0.0000	-.0010
-1.7071	-.2755	-.0027	4.2898	13.725145367.2720		.4312	39.5697
113643 846	8.0822	-1.6231	417.4331	-3.6257	.7517	0.0000	-.0004
-1.7318	-.2727	-.0060	4.2925	13.725145367.2720		.4312	39.5697
113643 866	8.0710	-1.7938	417.5068	-3.7138	.7471	0.0000	.0006
-1.7689	-.2705	-.0093	4.2952	13.725145367.3829		.4314	39.6123
113643 886	8.0609	-1.9511	417.5938	-3.7843	.7425	0.0000	-.0003
-1.8557	-.2677	-.0126	4.2979	13.725145351.7733		.4313	39.6137
113643 906	8.0472	-2.0939	417.6641	-3.8019	.7361	0.0000	-.0009
-1.9897	-.2687	-.0157	4.3002	13.725145351.8841		.4315	39.6563
113643 926	8.0446	-2.2105	417.7081	-3.8014	.7205	0.0000	-.0014
-2.1465	-.2711	-.0184	4.3022	13.725145351.8841		.4315	39.6563
113643 946	8.0449	-2.3117	417.7178	-3.8283	.7151	0.0000	-.0027
-2.3157	-.2751	-.0220	4.3054	13.725145351.8841		.4315	39.6563
113643 966	8.0263	-2.3863	417.7192	-3.9054	.7156	0.0000	-.0034
-2.4960	-.2759	-.0256	4.3091	13.725145351.8841		.4315	39.6563
113643 986	8.0022	-2.4362	417.7720	-3.9940	.7201	0.0000	-.0028
-2.6817	-.2762	-.0294	4.3121	13.725145351.9949		.4317	39.6989
113644 6	7.9861	-2.4527	417.8557	-4.0357	.7169	0.0000	-.0032
-2.8846	-.2762	-.0330	4.3144	13.725145351.9949		.4317	39.6989
113644 26	7.9602	-2.4544	417.9226	-4.0459	.7135	0.0000	-.0050
-3.1223	-.2752	-.0365	4.3171	13.725145351.9949		.4317	39.6989
113644 46	7.9221	-2.4344	417.9652	-4.1016	.7054	0.0000	-.0035
-3.3754	-.2727	-.0397	4.3203	13.719445351.9949		.4317	39.6989
113644 66	7.8860	-2.3860	418.0379	-4.1896	.6981	0.0000	-.0005
-3.6219	-.2704	-.0424	4.3230	13.684945352.1057		.4320	39.7416
113644 86	7.8754	-2.3005	418.1212	-4.2603	.6923	0.0000	.0014
-3.8434	-.2690	-.0447	4.3260	13.618545352.1057		.4320	39.7416

113644 106	7.8763	-2.1989	418.1608	-4.2778	.6875	0.0000	.0017
-4.0354	-.2660	-.0460	4.3286	13.549845352.1057		.4320	39.7416
113644 126	7.8742	-2.0731	418.1908	-4.2833	.6859	0.0000	.0002
-4.2023	-.2631	-.0481	4.3313	13.504445352.1057		.4320	39.7416
113644 146	7.8627	-1.9258	418.2198	-4.3395	.6820	0.0000	-.0010
-4.3532	-.2634	-.0512	4.3339	13.491845352.2164		.4322	39.7842
113644 166	7.8642	-1.7417	418.1821	-4.4277	.6761	0.0000	-.0024
-4.5025	-.2622	-.0541	4.3365	13.491745336.5076		.4318	39.7429
113644 186	7.8728	-1.5301	418.1084	-4.4984	.6691	0.0000	-.0020
-4.6512	-.2594	-.0564	4.3401	13.465345336.5076		.4318	39.7429
113644 206	7.8726	-1.3112	418.1197	-4.5159	.6701	0.0000	-.0011
-4.7873	-.2572	-.0588	4.3441	13.389845336.6183		.4320	39.7855
113644 226	7.8555	-1.0926	418.1959	-4.5155	.6764	0.0000	-.0015
-4.8829	-.2542	-.0612	4.3484	13.303245336.6183		.4320	39.7855
113644 246	7.8344	-.8775	418.2424	-4.5150	.6764	0.0000	-.0028
-4.9483	-.2525	-.0628	4.3508	13.262445336.6183		.4320	39.7855
113644 266	7.8315	-.6505	418.2800	-4.5150	.6706	0.0000	-.0023
-4.9972	-.2503	-.0643	4.3524	13.231445336.7289		.4323	39.8281
113644 286	7.8584	-.4277	418.3431	-4.5150	.6656	0.0000	-.0012
-5.0425	-.2505	-.0660	4.3530	13.157045336.7289		.4323	39.8281
113644 306	7.8957	-.2008	418.4093	-4.5150	.6658	0.0000	-.0003
-5.0603	-.2487	-.0675	4.3538	13.070645336.7289		.4323	39.8281
113644 326	7.9108	.0368	418.4551	-4.5150	.6690	0.0000	-.0013
-5.0456	-.2425	-.0676	4.3553	13.029845336.7289		.4323	39.8281
113644 346	7.9142	.2055	418.4853	-4.5150	.6734	0.0000	-.0027
-5.0028	-.2339	-.0672	4.3583	12.998845321.2529		.4323	39.8721
113644 366	7.9280	.4036	418.5135	-4.5150	.6790	0.0000	-.0018
-4.9322	-.2287	-.0676	4.3612	12.924545321.2529		.4323	39.8721
113644 386	7.9631	.6053	418.5615	-4.5150	.6816	0.0000	.0029
-4.8309	-.2265	-.0694	4.3634	12.838245321.2529		.4323	39.8721
113644 406	8.0019	.7704	418.6399	-4.5150	.6859	0.0000	.0049
-4.7028	-.2241	-.0705	4.3637	12.791645321.3635		.4326	39.9147
113644 426	8.0375	.9089	418.7234	-4.5150	.7004	0.0000	.0018
-4.5480	-.2208	-.0710	4.3639	12.732145321.3635		.4326	39.9147
113644 446	8.0584	1.0327	418.7627	-4.5150	.7144	0.0000	-.0020
-4.3716	-.2189	-.0720	4.3658	12.647145321.3635		.4325	39.9147
113644 466	8.0834	1.1445	418.7722	-4.5150	.7195	0.0000	-.0014
-4.1841	-.2178	-.0730	4.3683	12.578445321.3635		.4326	39.9147
113644 486	8.1090	1.2290	418.8249	-4.5150	.7209	0.0000	.0011
-3.9991	-.2170	-.0741	4.3693	12.534545321.4741		.4328	39.9573
113644 506	8.1298	1.2779	418.9079	-4.5150	.7319	0.0000	.0019
-3.8101	-.2152	-.0746	4.3702	12.459745321.4741		.4328	39.9573
113644 526	8.1556	1.3015	418.9746	-4.5091	.7485	0.0000	.0003
-3.6144	-.2087	-.0730	4.3722	12.374045321.4741		.4328	39.9573
113644 546	8.2057	1.2936	418.9966	-4.4523	.7615	0.0000	-.0006
-3.4118	-.1996	-.0704	4.3742	12.306645321.4741		.4328	39.9573
113644 566	8.2889	1.2642	419.0189	-4.3642	.7677	0.0000	.0017
-3.2006	-.1902	-.0678	4.3757	12.227345321.5846		.4330	39.9999
113644 586	8.4081	1.1961	419.0145	-4.2936	.7634	0.0000	.0032
-2.9813	-.1836	-.0663	4.3762	12.142145293.5606		.4328	40.0023
113644 606	8.5460	1.0885	418.9813	-4.2760	.7607	0.0000	.0010
-2.7677	-.1803	-.0659	4.3756	12.074945293.5606		.4328	40.0023
113644 626	8.6433	.9550	418.9563	-4.2764	.7662	0.0000	-.0027
-2.5648	-.1772	-.0659	4.3745	11.995645293.5606		.4328	40.0023
113644 646	8.6723	.8115	419.0046	-4.2769	.7820	0.0000	-.0027
-2.3774	-.1745	-.0654	4.3738	11.910545293.6710		.4330	40.0450
113644 666	8.6786	.6673	419.0882	-4.2769	.7939	0.0000	-.0013
-2.2070	-.1696	-.0642	4.3764	11.843345293.6710		.4330	40.0450
113644 686	8.7030	.5009	419.1549	-4.2769	.7984	0.0000	-.0012
-2.0630	-.1655	-.0628	4.3806	11.764245293.6710		.4330	40.0450
113644 706	8.7329	.3080	419.1670	-4.2769	.7943	0.000	-.0004
-1.9418	-.1622	-.0618	4.3834	11.679145293.6710		.4330	40.0450
113644 726	8.7419	.0940	419.1401	-4.2769	.7949	0.0000	.0039
-1.8357	-.1587	-.0602	4.3815	11.612045275.0091		.4328	40.0466
113644 746	8.7539	-.1195	419.0932	-4.2769	.8018	0.0000	.0022
-1.7451	-.1535	-.0588	4.3795	11.532945275.0091		.4328	40.0466

113644 766	8.7739	-.3505	419.0625	-4.2769	.8156	0.0000	-.0037
-1.6864	-.1473	-.0566	4.3789	11.447945293.6719		.4332	40.0450
113644 786	8.7786	-.5907	419.0360	-4.2769	.8190	0.0000	-.0048
-1.6607	-.1423	-.0556	4.3829	11.380945275.0091		.4328	40.0466
113644 806	8.7502	-.8400	419.0184	-4.2769	.7945	0.0000	.0018
-1.6615	-.1348	-.0537	4.3889	11.301845275.0091		.4328	40.0466
113644 826	8.7298	-1.0738	419.0535	-4.2769	.7743	0.0000	.0043
-1.6807	-.1291	-.0529	4.3930	11.216945275.1194		.4330	40.0892
113644 846	8.7272	-1.2934	419.1332	-4.2828	.7873	0.0000	.0004
-1.7187	-.1266	-.0527	4.3914	11.170845275.1194		.4330	40.0892
113644 866	8.7146	-1.5205	419.2000	-4.3396	.8152	0.0000	-.0033
-1.7743	-.1277	-.0536	4.3882	11.111645275.1194		.4330	40.0892
113644 886	8.6893	-1.7418	419.2166	-4.4277	.8100	0.0000	-.0031
-1.8560	-.1251	-.0533	4.3884	11.027145275.1194		.4330	40.0892
113644 906	8.6742	-1.9330	419.2162	-4.4984	.7912	0.0000	-.0020
-1.9738	-.1215	-.0524	4.3915	10.932245275.1194		.4330	40.0892
113644 926	8.6656	-2.1052	419.2213	-4.5159	.7940	0.0000	-.0026
-2.1355	-.1170	-.0511	4.3958	10.840445275.1194		.4330	40.0892
113644 946	8.6498	-2.2618	419.3004	-4.5155	.8016	0.0000	-.0069
-2.3129	-.1125	-.0492	4.3980	10.755145275.2297		.4333	40.1318
113644 966	8.6378	-2.4013	419.4558	-4.5424	.7913	0.0000	-.0081
-2.4590	-.1082	-.0473	4.3973	10.688645275.3400		.4335	40.1744
113644 986	8.6115	-2.5271	419.6267	-4.6196	.7717	0.0000	-.0051
-2.5464	-.1035	-.0458	4.3960	10.609745275.3400		.4335	40.1744
113645 6	8.5581	-2.6443	419.7122	-4.7082	.7707	0.0000	-.0020
-2.5843	-.0977	-.0441	4.3963	10.525045256.8047		.4335	40.2186
113645 26	8.5013	-2.7288	419.7328	-4.7500	.7729	0.0000	-.0035
-2.5970	-.0916	-.0425	4.3983	10.458145256.8047		.4335	40.2186
113645 46	8.4688	-2.7983	419.7175	-4.7817	.7633	0.0000	-.0047
-2.6131	-.0874	-.0414	4.4000	10.379345256.8047		.4335	40.2186
113645 66	8.4600	-2.8753	419.7082	-4.8579	.7527	0.0000	-.0048
-2.6390	-.0854	-.0413	4.4010	10.294745256.8047		.4335	40.2186
113645 86	8.4477	-2.9584	419.7077	-4.9464	.7490	0.0000	-.0074
-2.6769	-.0821	-.0401	4.4019	10.234645256.8047		.4335	40.2186
113645 106	8.4071	-3.0469	419.7079	-4.9882	.7458	0.0000	-.0074
-2.7171	-.0784	-.0385	4.4029	10.174645256.8047		.4335	40.2186
113645 126	8.3293	-3.1199	419.7079	-5.0199	.7457	0.0000	-.0035
-2.7486	-.0745	-.0367	4.4017	10.105845256.8047		.4335	40.2186
113645 146	8.2445	-3.1695	419.7079	-5.0962	.7499	0.0000	-.0025
-2.7736	-.0726	-.0359	4.4001	10.020545256.8047		.4335	40.2186
113645 166	8.1760	-3.2038	419.7336	-5.1847	.7442	0.0000	-.0035
-2.8039	-.0699	-.0351	4.3995	9.931745256.8047		.4335	40.2186
113645 186	8.1184	-3.2466	419.8111	-5.2266	.7282	0.0000	-.0017
-2.8266	-.0665	-.0340	4.3992	9.858145256.9148		.4338	40.2612
113645 206	8.0649	-3.2727	419.9086	-5.2583	.7167	0.0000	.0020
-2.8439	-.0625	-.0323	4.3997	9.786045238.3959		.4338	40.3054
113645 226	8.0137	-3.2773	419.9643	-5.3345	.7133	0.0000	.0023
-2.8850	-.0588	-.0308	4.4023	9.700745238.3959		.4338	40.3054
113645 246	7.9761	-3.2797	420.0017	-5.4231	.7125	0.0000	-.0008
-2.9498	-.0526	-.0281	4.4052	9.627045238.3959		.4338	40.3054
113645 266	7.9426	-3.2937	420.0738	-5.4650	.7159	0.0000	-.0052
-3.0133	-.0461	-.0252	4.4063	9.554845238.5059		.4341	40.3480
113645 286	7.9113	-3.3031	420.1619	-5.4967	.7129	0.0000	-.0057
-3.0689	-.0404	-.0225	4.4067	9.469645238.5059		.4341	40.3480
113645 306	7.8866	-3.2849	420.2542	-5.5730	.7030	0.0000	-.0023
-3.1227	-.0377	-.0212	4.4065	9.375045238.6159		.4343	40.3906
113645 326	7.8637	-3.2346	420.3407	-5.6616	.6975	0.0000	-.0011
-3.1774	-.0358	-.0204	4.4072	9.283145238.6159		.4343	40.3906
113645 346	7.8343	-3.1803	420.4059	-5.7094	.6987	0.0000	-.0024
-3.2424	-.0336	-.0195	4.4096	9.197645238.6159		.4343	40.3906
113645 366	7.7938	-3.1207	420.4222	-5.7706	.6958	0.0000	-.0021
-3.3163	-.0304	-.0182	4.4147	9.131045238.6159		.4343	40.3906
113645 386	7.7609	-3.0526	420.4067	-5.8579	.6948	0.0000	-.0011
-3.3890	-.0248	-.0156	4.4204	9.052145238.6159		.4343	40.3906
113645 406	7.7386	-2.9684	420.4914	-5.9286	.6909	0.0000	-.0010
-3.4530	-.0218	-.0144	4.4238	8.967245220.1132		.4343	40.4348

113645 426	7.7170	-2.8894	420.4174	-5.9521	.6837	0.0000	-.0003
-3.5058	-.0193	-.0132	4.4247	8.900345220.1132		.4343	40.4348
113645 446	7.6816	-2.8094	420.4575	-6.0086	.6786	0.0000	.0005
-3.5504	-.0159	-.0116	4.4247	8.821445220.1132		.4343	40.4348
113645 465	7.6338	-2.7182	420.5238	-6.0965	.6781	0.0000	-.0011
-3.5956	-.0119	-.0096	4.4256	8.710045220.2231		.4346	40.4774
113645 486	7.5847	-2.6226	420.6065	-6.1673	.6744	0.0000	-.0020
-3.6555	-.0082	-.0078	4.4294	8.595045220.2231		.4346	40.4774
113645 506	7.5552	-2.5179	420.6721	-6.1849	.6695	0.0000	.0001
-3.7323	-.0035	-.0051	4.4342	8.505145220.2231		.4346	40.4774
113645 526	7.5313	-2.3999	420.6885	-6.2120	.6708	0.0000	.0017
-3.8180	.0036	-.0006	4.4390	8.439145220.2231		.4346	40.4774
113645 546	7.5184	-2.2611	420.7137	-6.2889	.6743	0.0000	-.0021
-3.8959	.0089	.0028	4.4432	8.360545220.2231		.4346	40.4774
113645 566	7.5063	-2.1321	420.7853	-6.3777	.6745	0.0000	-.0054
-3.9672	.0105	.0046	4.4473	8.249245220.3330		.4348	40.5200
113645 586	7.4939	-2.0011	420.8474	-6.4197	.6675	0.0000	-.0043
-4.0226	.0120	.0052	4.4513	8.134345220.3330		.4348	40.5200
113645 606	7.4746	-1.8571	420.8540	-6.4240	.6639	0.0000	-.0018
-4.0628	.0132	.0063	4.4554	8.038945201.7367		.4346	40.5216
113645 626	7.4676	-1.6864	420.8891	-6.4229	.6641	0.0000	-.0019
-4.1005	.0133	.0065	4.4590	7.944645201.8465		.4348	40.5642
113645 646	7.4631	-1.5314	421.0368	-6.4228	.6689	0.0000	-.0020
-4.1422	.0137	.0071	4.4609	7.849745201.9562		.4351	40.6067
113645 666	7.4456	-1.3804	421.2269	-6.4229	.6671	0.0000	-.0016
-4.1955	.0166	.0097	4.4624	7.727545202.0660		.4353	40.6493
113645 686	7.4413	-1.2226	421.3786	-6.4504	.6648	0.0000	-.0016
-4.2564	.0203	.0131	4.4638	7.619945202.0660		.4353	40.6493
113645 706	7.4620	-1.0470	421.4925	-6.5278	.6626	0.0000	-.0019
-4.3117	.0210	.0142	4.4658	7.497245202.1757		.4355	40.6919
113645 726	7.4745	-.8675	421.5833	-6.6167	.6620	0.0000	-.0017
-4.3499	.0210	.0146	4.4671	7.369245202.1757		.4355	40.6919
113645 746	7.4770	-.6992	421.6535	-6.6586	.6590	0.0000	-.0015
-4.3872	.0222	.0164	4.4683	7.227045202.2854		.4358	40.7344
113645 766	7.4991	-.5241	421.6976	-6.6629	.6563	0.0000	-.0029
-4.4188	.0225	.0171	4.4700	7.119545183.7053		.4356	40.7361
113645 786	7.5413	-.3301	421.7111	-6.6619	.6609	0.0000	-.0043
-4.4426	.0224	.0174	4.4732	7.024845183.7053		.4356	40.7361
113645 806	7.5611	-.1350	421.6962	-6.6618	.6728	0.0000	-.0035
-4.4621	.0233	.0188	4.4747	6.909745183.7053		.4356	40.7361
113645 826	7.5715	.0371	421.6965	-6.6618	.6780	0.0000	.0000
-4.4860	.0267	.0236	4.4734	6.768245183.7053		.4356	40.7361
113645 846	7.5877	.1976	421.7585	-6.6618	.6770	0.0000	.0016
-4.5114	.0293	.0266	4.4698	6.639645183.8149		.4358	40.7786

OUTPUT LISTING

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               AIRCRAFT A CHECK CASE                                                                         09/17/74
                                      NEWTON-RAPHSON DIGITAL DERIVATIVE MATCHING
                                                      1 APR 1974

INPUT DATA (T INDICATES TRUE OR YES, F INDICATES FALSE OR NO)

   LATERAL       CASE
   DATA SOURCE     CARD? T         TAPE? F
   DATA RATE IS   0. SAMPLES/SECOND ON SOURCE FILE (IF 0, DETERMINED FROM TIMES ON THE SOURCE FILE)
       DIVIDED BY THINNING FACTOR OF  1
   ON INPUT TAPE:  15 DATA WORDS PER RECORD.   SPECIAL SIGNAL ORDER DEFAULT? F


PROGRAM OPTIONS

   APRIORI WEIGHTING =0.                   0 TIME HALVINGS IN EAT.
   ITERATIONS =  6  (ITERATION WILL STOP IF ERROR SUM CHANGES BY LESS THAN A FACTOR OF  .10E-02)
   CASE WILL BE STOPPEC IF ERROR SUM IS GREATER THAN  .10E+21


OUTPUT

   PLOTS? T  (NO PLOTS UNLESS FINAL ERROR SUM IS LESS THAN .100E+06)
       NUMBER OF CONTROLS AND EXTRA SIGNALS TO BE PLOTTED =  8
       SECONDS PER CENTIMETER = 1.00
   PRINTED FLIGHT AND FINAL COMPUTED TIME HISTORIES? F
   EXTRA OUTPUT OF INTERMEDIATE STEPS FOR A DIAGNOSTIC AID? F
   PUNCHED FINAL NON-DIMENSIONAL DERIVATIVES AND CONFIDENCE LEVELS? F
   PUNCHED FINAL DIMENSIONAL MATRICES? F


FLIGHT CONDITION AND VEHICLE CHACTERISTICS (0. INDICATES VALUE OBTAINED FROM TIME HISTORY ON QBAR,V OR MACH)
                                          (MACH,ALPHA,CG AND PARAM ARE FOR REFERENCE ONLY, NOT USED IN PROGRAM)
   METRIC UNITS? F
   DYNAMIC PRESSURE =       520.0       VELOCITY = 4665.0
   MACH = 0.000                         ALPHA = 999.00  (IF 999. , OBTAINED FROM TIME HISTORY)
   CENTER OF GRAVITY =  .250            OTHER IDENTIFYING PARAMETER = 0.
   WING AREA =      .0                  SPAN =     .00      CHORD =   .00
   IX =*********                        IY =**********      IZ =**********,   IXZ =      0.0
   WEIGHT =*********
   INSTRUMENT OFFSETS FROM CG
       X-DIRECTION OFFSETS (+ = INSTRUMENT IS FORWARD OF CG)
           ALPHA   0.000  AN   0.000
           BETA    0.000  AY   0.000
       Z-DIRECTION OFFSETS ( + = INSTRUMENT IS BELOW CG)
           BETA    0.000  AY   0.000

SIGNAL SCALING AND BIASES
 SIGNALS      BETA    P       R       PHI     AY      PDOT    RDOT    DA      DR      DC1     DC2     ALFA    V       MACH    QBAR
 VAR BIAS                                     T       T       T
 VAR I.C.      F       F       F       F
 FIXED BIAS   0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
 SCALE FACT   1.00    1.00    1.00    1.00    1.00    1.00    1.00
 PLOT LIMITS
   MINIMUM    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
   MAXIMUM    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00


 MANEUVER   1  START TIME    0    0    0    0  STOP TIME    0    0    5  875
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                    AIRCRAFT A CHECK CASE

 INPUT MATRICES :
A                                     4  BY  4
            -.3800E-01    .1110E+00  -.1000E+01    .6900E-02
            -.1679E+02   -.2410E+00   .4000E+00   0.
             .1550E+01   -.2840E-02  -.4200E-01   0.
            -0.           .1000E+01  -0.          -0.
B                                     4  BY  5
            -0.           .1480E-01  -0.          -0.          -0.
             .1276E+02    .2008E+02  -0.          -0.          -0.
             .3577E+00   -.2445E+01  -0.          -0.          -0.
            -0.          -0.          -0.          -0.          -0.
D1                                    7  BY  7
             .2160E+04   0.           0.           0.           0.           0.           0.
            0.            .6500E+01   0.           0.           0.           0.           0.
            0.           0.            .4860E+04   0.           0.           0.           0.
            0.           0.           0.            .1350E+03   0.           0.           0.
            0.           0.           0.           0.            .2265E+02   0.           0.
            0.           0.           0.           0.           0.            .2700E+01   0.
            0.           0.           0.           0.           0.           0.            .1980E+03
                                      TOTAL NUMBER OF POINTS FOR MANEUVER  1 =    235
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                    AIRCRAFT A CHECK CASE                                                                    09/17/74

     STARTING VALUES    MACH = 0.000    ALPHA =   0.00    PARAM =    0.0000    CG =  .250

DIMENSIONAL DERIVATIVES / SEC / SEC**2
        BETA           P              R               DA              DR              DC1             DC2             DELTA-O
 Y     -.038000       .111000       -1.000000*      -0.000000        .014800        -0.000000*      -0.000000*      -0.000000
 L   -16.790000      -.241000        .400000        12.760000      20.080000        -0.000000*      -0.000000*      -0.000000
 N     1.550000      -.002840       -.042000         .357700       -2.445000        -0.000000*      -0.000000*      -0.000000

NON-DIMENSIONAL DERIVATIVES / DEG (ROTARY /RAD)
        BETA           P              R               DA              DR              DC1             DC2             DELTA-O
CY**************    0.000000      0.000000*       0.000000    **************      0.000000*       0.000000*       0.000000
CL************** ************** ************** ************** **************      0.000000*       0.000000*       0.000000
CN************** ************** ************** ************** **************      0.000000*       0.000000*       0.000000

                            ( * ) INDICATES DERIVATIVE HELD FIXED DURING MATCH          NUMBER OF UNKNOWNS = 21

                ENTERING ITERATION LOOP

 DIMENSIONAL DERIVATIVE MATRICES PER RADIAN, BIASES IN RADIANS.


A                                  4  BY  4
              -.3800E-01   .1110E+00  -.1000E+01   .6900E-02
              -.1679E+02  -.2410E+00   .4000E+00  0.
               .1550E+01  -.2840E-02  -.4200E-01  0.
             -0.           .1000E+01 -0.          -0.
B                                  4  BY  5
             -0.           .1480E-01 -0.          -0.          -0.
               .1276E+02   .2008E+02 -0.          -0.          -0.
               .3577E+00  -.2445E+01 -0.          -0.          -0.
             -0.          -0.        -0.          -0.          -0.
                 AY           PDOT         RDOT
VARIABLE BIAS   0.           0.           0.
                                                                                       WEIGHTED ERROR SUM =    .6853E+01
ERRORS
   .1051E-03   .1905E-01   .1562E-03   .4192E-01   .9587E-03   .1459E-01   .1087E-03
WEIGHTED ERRORS
   .2271E+00   .1238E+00   .7593E+00   .5660E+01   .2172E-01   .3940E-01   .2153E-01


                                                  ITERATION NUMBER   1 COMPLETED
A                                  4  BY  4
              -.4692E-01   .1023E+00  -.1000E+01   .6900E-02
              -.2424E+02  -.1403E+00   .2220E+01  0.
               .1289E+01  -.3239E-03  -.1284E+00  0.
             -0.           .1000E+01 -0.          -0.
B                                  4  BY  5
               .2250E-02   .1535E-01 -0.          -0.          -.3084E-02
               .1430E+02   .1740E+02 -0.          -0.           .4124E+00
               .4389E+00  -.2173E+01 -0.          -0.          -.6923E-02
             -0.          -0.        -0.          -0.          -.8447E-02
                 AY           PDOT         RDOT
VARIABLE BIAS    .5277E+00  -.2469E-01  -.4478E-02
                                                                                       WEIGHTED ERROR SUM =    .3322E+00
ERRORS
   .4787E-05   .1302E-02   .7344E-05   .1885E-02   .3279E-03   .3593E-02   .3082E-04
WEIGHTED ERRORS
   .1034E-01   .8462E-02   .3569E-01   .2545E+00   .7428E-02   .9701E-02   .6103E-02


                                                  ITERATION NUMBER   2 COMPLETED
```

```
A                                    4  BY  4
           -.4698E-01   .1019E+00  -.1000E+01   .6900E-02
           -.2446E+02  -.1014E+00   .2438E+01  0.
            .1295E+01   .6551E-03  -.1454E+00  0.
          -0.           .1000E+01 -0.          -0.
B                                    4  BY  5
            .2786E-02   .1586E-01 -0.          -0.           -.3038E-02
            .1453E+02   .1785E+02 -0.          -0.            .4110E+00
            .4927E+00  -.2133E+01 -0.          -0.           -.7518E-02
          -0.         -0.         -0.          -0.           -.7921E-02
               AY          PDOT        ROOT
VARIABLE BIAS    .5193E+00  -.2585E-01  -.4465E-02
                                                                                     WEIGHTED ERROR SUM =   .5911E-01
ERRORS
   .4609E-05   .8052E-03   .2007E-05   .6540E-04   .3544E-03   .4336E-02   .2834E-04
WEIGHTED ERRORS
   .9956E-02   .5234E-02   .9752E-02   .8828E-02   .8027E-02   .1171E-01   .5611E-02

                                              ITERATION NUMBER   3 COMPLETED
A                                    4  BY  4
           -.4671E-01   .1026E+00  -.1000E+01   .6900E-02
           -.2432E+02  -.1018E+00   .2456E+01  0.
            .1290E+01   .4784E-03  -.1519E+00  0.
          -0.           .1000E+01 -0.          -0.
B                                    4  BY  5
            .2732E-02   .1593E-01 -0.          -0.           -.3034E-02
            .1447E+02   .1787E+02 -0.          -0.            .4090E+00
            .5052E+00  -.2126E+01 -0.          -0.           -.7531E-02
          -0.         -0.         -0.          -0.           -.8406E-02
               AY          PDOT        ROOT
VARIABLE BIAS    .5178E+00  -.2581E-01  -.4472E-02
                                                                                     WEIGHTED ERROR SUM =   .5890E-01
ERRORS
   .4491E-05   .8141E-03   .2089E-05   .6286E-04   .3535E-03   .4314E-02   .2837E-04
WEIGHTED ERRORS
   .9701E-02   .5292E-02   .1015E-01   .8487E-02   .8006E-02   .1165E-01   .5617E-02

                                              ITERATION NUMBER   4 COMPLETED
A                                    4  BY  4
           -.4670E-01   .1026E+00  -.1000E+01   .6900E-02
           -.2432E+02  -.1015E+00   .2463E+01  0.
            .1290E+01   .4523E-03  -.1514E+00  0.
          -0.           .1000E+01 -0.          -0.
B                                    4  BY  5
            .2752E-02   .1594E-01 -0.          -0.           -.3035E-02
            .1447E+02   .1787E+02 -0.          -0.            .4092E+00
            .5060E+00  -.2125E+01 -0.          -0.           -.7550E-02
          -0.         -0.         -0.          -0.           -.8423E-02
               AY          PDOT        ROOT
VARIABLE BIAS    .5180E+00  -.2582E-01  -.4472E-02
                                                                                     WEIGHTED ERROR SUM =   .5890E-01
ERRORS
   .4494E-05   .8136E-03   .2085E-05   .6275E-04   .3539E-03   .4321E-02   .2835E-04
WEIGHTED ERRORS
   .9708E-02   .5288E-02   .1014E-01   .8472E-02   .8017E-02   .1167E-01   .5614E-02

                                              ITERATION NUMBER   5 COMPLETED
```

```
 ITERATION TERMINATING, ERROR WITHIN  .001000  BOUND.

CONFIDENCE LEVELS FOR NEXT TO LAST ITERATION
    (DIMENSIONAL)

AC                                3  BY  3
             .5401E-03   .7999E-03  0.
             .1508E+00   .9145E-02   .2088E+00
             .1056E-01   .7281E-03   .1637E-01
BC                                3  BY  5
             .9128E-03   .1019E-02  0.          0.          .2101E-03
             .3688E+00   .3906E+00  0.          0.          .7108E-02
             .3197E-01   .3726E-01  0.          0.          .5759E-03

    (NON-DIMENSIONAL)
AC                                3  BY  3
             .2629E+07   .7999E-03  0.
             .5063E+10   .1641E+18   .3746E+19
             .3543E+09   .1306E+17   .2938E+18
BC                                3  BY  5
             .4442E+07   .4959E+07  0.          0.          .5859E+08
             .1238E+11   .1311E+11  0.          0.          .1367E+11
             .1073E+10   .1251E+10  0.          0.          .1107E+10
```

```
                         AIRCRAFT A CHECK CASE                                                                        09/17/74

          FINAL VALUES      MACH = 0.000      ALPHA =    0.00      PARAM =      0.0000      CG =  .250

DIMENSIONAL DERIVATIVES / SEC / SEC**2
          BETA              P               R               DA              DR              DC1             DC2             DELTA-O
 Y      -.046703         .102595       -1.000000*        .002753         .015943       -0.000000*      -0.000000*        -.003035
 L    -24.320923        -.101510        2.463745       14.469799       17.868306       -0.000000*      -0.000000*         .409219
 N      1.289852         .000448        -.151448         .506167       -2.124599       -0.000000*      -0.000000*        -.007553

NON-DIMENSIONAL DERIVATIVES / DEG (ROTARY /RAD)
          BETA              P               R               DA              DR              DC1             DC2             DELTA-O
CY**************        0.000000        0.000000* ************** **************        0.000000*       0.000000* **************
CL************** **************  ************** ************** **************        0.000000*       0.000000* **************
CN************** **************  ************** ************** **************        0.000000*       0.000000* **************

                                           ( * ) INDICATES DERIVATIVE HELD FIXED DURING MATCH
VARIABLE BIAS    .5179E+00   -.2582E-01   -.4472E-02
FINAL DIMENSIONAL MATRICES
A                                    4  BY  4
             -.4670E-01   .1026E+00  -.1000E+01   .6900E-02
             -.2432E+02  -.1015E+00   .2464E+01  0.
              .1290E+01   .4483E-03  -.1514E+00  0.
            -0.           .1000E+01 -0.          -0.
B                                    4  BY  5
              .2753E-02   .1594E-01 -0.          -0.           -.3035E-02
              .1447E+02   .1787E+02 -0.          -0.            .4092E+00
              .5062E+00  -.2125E+01 -0.          -0.           -.7553E-02
            -0.         -0.          -0.         -0.           -.8423E-02

DEGREES          AY          PDOT         RDOT
VARIABLE BIAS    .5179E+00   -.1479E+01   -.2562E+00
                                                                                      WEIGHTED ERROR SUM =    .5890E-01
ERRORS
   .4494E-05   .8135E-03   .2085E-05   .6274E-04   .3540E-03   .4322E-02   .2835E-04
WEIGHTED ERRORS
   .9707E-02   .5287E-02   .1014E-01   .8471E-02   .8017E-02   .1167E-01   .5613E-02
                                                                ERRORS
     6.85        .33         .06         .06         .06        .06
```

```
        AIRCRAFT B CHECK CASE
                              NEWTON-RAPHSON DIGITAL DERIVATIVE MATCHING                                09/17/74
                                                  1 APR 1974
INPUT DATA (T INDICATES TRUE OR YES, F INDICATES FALSE CR NO)

    LONGITUDINAL CASE
    DATA SOURCE    CARD? T        TAPE? F
    DATA RATE IS  50. SAMPLES/SECOND ON SOURCE FILE (IF 0, DETERMINED FROM TIMES ON THE SOURCE FILE)
         DIVIDED BY THINNING FACTOR OF  1
    ON INPUT TAPE:  25 DATA WORDS PER RECORD.    SPECIAL SIGNAL ORDER DEFAULT? T

PROGRAM OPTIONS

    APRIORI WEIGHTING = .10E+01              0 TIME HALVINGS IN EAT.
    ITERATIONS =  6  (ITERATION WILL STCP IF ERROR SUM CHANGES BY LESS THAN A FACTOR OF  .10E-02)
    CASE WILL BE STOPPED IF ERROR SUM IS GREATER THAN  .10E+21

OUTPUT

    PLOTS? T  (NO PLOTS UNLESS FINAL ERROR SUM IS LESS THAN .100E+06)
         NUMBER OF CONTROLS AND EXTRA SIGNALS TO BE PLOTTED =  8
         SECONDS PER CENTIMETER =  .50
    PRINTED FLIGHT AND FINAL COMPUTED TIME HISTORIES? F
    EXTRA OUTPUT OF INTERMEDIATE STEPS FOR A DIAGNOSTIC AID? F
    PUNCHED FINAL NON-DIMENSIONAL DERIVATIVES AND CONFICENCE LEVELS? T
    PUNCHED FINAL DIMENSIONAL MATRICES? F

FLIGHT CONDITION AND VEHICLE CHACTERISTICS (0. INDICATES VALUE OBTAINED FROM TIME HISTORY ON QBAR,V OR MACH)
                                          (MACH,ALPHA,CG AND PARAM ARE FOR REFERENCE ONLY, NOT USED IN PROGRAM)
    METRIC UNITS? F
    DYNAMIC PRESSURE =        39.0      VELOCITY =  415.2
    MACH =  .429                        ALPHA =    7.86  (IF 999. , OBTAINED FROM TIME HISTORY)
    CENTER OF GRAVITY =  .260           OTHER IDENTIFYING PARAMETER =  .500E+01
    WING AREA =   85.0                  SPAN =   16.05      CHORD =  5.98
    IX =     275.0                      IY =     1932.0     IZ =     2228.0     IXZ =     11.6
    WEIGHT =   2470.0
    INSTRUMENT OFFSETS FROM CG
         X-DIRECTION OFFSETS (+ = INSTRUMENT IS FORWARD OF CG)
              ALPHA    0.000  AN    -.010
              BETA     0.000  AY    0.000
         Z-DIRECTION OFFSETS ( + = INSTRUMENT IS BELOW CG)
              BETA     0.000  AY    0.000

SIGNAL SCALING AND BIASES
 SIGNALS      ALFA     Q        V       THET     AN      QDOT     AX       DE       DC       DC1      DC2      PHI      ALT      MACH     QBAR
 VAR BIAS                                        T        T        T
 VAR I.C.      F       F        F        F
 FIXED BIAS   0.00     0.00     0.00     0.00    0.00     0.00     0.00     0.00     0.00     0.00     0.00
 SCALE FACT   1.00     1.00     1.00     1.00    1.00     1.00     1.00
 PLOT LIMITS
   MINIMUM    0.00     0.00     0.00     0.00    0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
   MAXIMUM    0.00     0.00  1000.00     0.00    0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00

MANEUVER   1   START TIME    11    36    38  750   STOP TIME    11    36    45  840
```

```
                     AIRCRAFT B CHECK CASE

 INPUT MATRICES :
A                                   4  BY  4
           -.4204E+00   .1000E+01 -0.          .2210E-02
           -.3794E+01  -.3632E+00  0.         0.
            .1567E+02  0.         -0.         -.3216E+02
           0.           .9916E+00  0.         0.
B                                   4  BY  5
           -.6489E-01 -0.         -0.         -0.          .7346E-01
           -.6281E+01  0.          0.          0.          .1817E+00
            .8354E+01 -0.         -0.         -0.         -.2394E+01
          -0.           .1000E+01 -0.         -0.         -0.
D1                                  5  BY  5
            .1000E+06  0.          0.          0.          0.
           0.           .7000E+05  0.          0.          0.
           0.          0.         -0.          0.          0.
           0.          0.          0.           .4000E+06  0.
           0.          0.          0.          0.           .1000E+05
APRA                                4  BY  4
            .5000E+05 -0.         -0.         -0.
            .3000E+00   .1000E+04 -0.         -0.
           0.         -0.         -0.         -0.
           0.         -0.         -0.         -0.
APRB                                4  BY  8
            .1000E+05 -0.         -0.         -0.         -0.         -0.         -0.         -0.
            .1000E+01 -0.         -0.         -0.         -0.         -0.         -0.         -0.
           0.         -0.         -0.         -0.         -0.         -0.         -0.         -0.
           0.         -0.         -0.         -0.         -0.         -0.         -0.         -0.
                                       TOTAL NUMBER OF POINTS FOR MANEUVER  1 =   354
```

```
                         AIRCRAFT B CHECK CASE                                                                              09/17/74

          STARTING VALUES     MACH =  .429     ALPHA =   7.86     PARAM =    5.0000     CG =  .260

DIMENSIONAL DERIVATIVES / SEC / SEC**2
              ALFA            Q              V               DE             DC             DC1            DC2             DELTA-0
 N          .420350       -1.000000*     0.000000*        .064890       0.000000*      0.000000*      0.000000*        -.073460
 M        -3.794300        -.363210      0.000000*      -6.280730       0.000000*      0.000000*      0.000000*         .181650
 A       -15.668030*      -0.000000*     0.000000*      -8.353920*      0.000000*      0.000000*      0.000000*        2.393650*

NON-DIMENSIONAL DERIVATIVES / DEG (ROTARY /RAD)
              ALFA            Q              V               DE             DC             DC1            DC2             DELTA-0
CN          .070547        0.000000*     0.000000*        .010890       0.000000*      0.000000*      0.000000*        -.706389
CM         -.006354       -4.839157      0.000000*       -.010518       0.000000*      0.000000*      0.000000*         .017429
CA         -.006333*      -0.000000*     0.000000*       -.003377*      0.000000*      0.000000*      0.000000*         .055437*

                                   ( * ) INDICATES DERIVATIVE HELD FIXED DURING MATCH           NUMBER OF UNKNOWNS =  9

                      ENTERING ITERATION LOOP

 DIMENSIONAL DERIVATIVE MATRICES PER RADIAN. BIASES IN RADIANS.

A                                  4  BY  4
             -.4204E+00   .1000E+01 -0.            .2210E-02
             -.3794E+01  -.3632E+00  0.           0.
              .1567E+02  0.         -0.           -.3216E+02
             0.           .9916E+00  0.           0.
B                                  4  BY  5
             -.6489E-01 -0.         -0.           -0.            .7346E-01
             -.6281E+01  0.          0.            0.            .1817E+00
              .8354E+01 -0.         -0.           -0.           -.2394E+01
            -0.           .1000E+01 -0.           -0.           -0.
                AN
VARIABLE BIAS    .1000E+01                                                          WEIGHTED ERROR SUM =   .2193E+03

ERRORS
   .1810E-04   .7834E-04   .4079E+02   .4008E-03   .5171E-02
WEIGHTED ERRORS
   .1810E+01   .5484E+01  0.           .1603E+03   .5171E+02

                                           ITERATION NUMBER   1 COMPLETED
A                                  4  BY  4
             -.4555E+00   .1000E+01 -0.            .2210E-02
             -.3229E+01  -.3851E+00  0.           0.
              .1567E+02  0.         -0.           -.3216E+02
             0.           .9916E+00  0.           0.
B                                  4  BY  5
             -.5102E-01 -0.         -0.           -0.            .8519E-01
             -.6259E+01  0.          0.            0.            .1012E+00
              .8354E+01 -0.         -0.           -0.           -.2394E+01
            -0.           .1000E+01 -0.           -0.            .1491E-02
                AN
VARIABLE BIAS    .1012E+01                                                          WEIGHTED ERROR SUM =   .6688E+01

ERRORS
   .6808E-05   .1238E-04   .2221E+02   .6785E-05   .2427E-03
WEIGHTED ERRORS
   .6808E+00   .8665E+00  0.           .2714E+01   .2427E+01

                                           ITERATION NUMBER   2 COMPLETED
```

```
A                                     4  BY  4
             -.4511E+00   .1000E+01 -0.         .2210E-02
             -.3222E+01  -.4853E+00  0.        0.
              .1567E+02  0.         -0.        -.3216E+02
             0.           .9916E+00  0.        0.
B                                     4  BY  5
             -.5149E-01 -0.         -0.        -0.           .8460E-01
             -.6271E+01  0.          0.         0.           .9628E-01
              .8354E+01 -0.         -0.        -0.          -.2394E+01
            -0.           .1000E+01 -0.        -0.           .1631E-02
                 AN
VARIABLE BIAS     .1013E+01
                                                                                        WEIGHTED ERROR SUM =   .5923E+01
ERRORS
   .5865E-05   .1364E-04   .2252E+02   .6054E-05   .1961E-03
WEIGHTED ERRORS
   .5865E+00   .9547E+00  0.           .2421E+01   .1961E+01

                                                   ITERATION NUMBER   3 COMPLETED
A                                     4  BY  4
             -.4502E+00   .1000E+01 -0.         .2210E-02
             -.3196E+01  -.4956E+00  0.        0.
              .1567E+02  0.         -0.        -.3216E+02
             0.           .9916E+00  0.        0.
B                                     4  BY  5
             -.5192E-01 -0.         -0.        -0.           .8431E-01
             -.6260E+01  0.          0.         0.           .9292E-01
              .8354E+01 -0.         -0.        -0.          -.2394E+01
            -0.           .1000E+01 -0.        -0.           .1526E-02
                 AN
VARIABLE BIAS     .1012E+01
                                                                                        WEIGHTED ERROR SUM =   .5902E+01
ERRORS
   .5931E-05   .1376E-04   .2251E+02   .6012E-05   .1941E-03
WEIGHTED ERRORS
   .5931E+00   .9632E+00  0.           .2405E+01   .1941E+01

                                                   ITERATION NUMBER   4 COMPLETED
A                                     4  BY  4
             -.4503E+00   .1000E+01 -0.         .2210E-02
             -.3193E+01  -.4999E+00  0.        0.
              .1567E+02  0.         -0.        -.3216E+02
             0.           .9916E+00  0.        0.
B                                     4  BY  5
             -.5195E-01 -0.         -0.        -0.           .8430E-01
             -.6264E+01  0.          0.         0.           .9222E-01
              .8354E+01 -0.         -0.        -0.          -.2394E+01
            -0.           .1000E+01 -0.        -0.           .1521E-02
                 AN
VARIABLE BIAS     .1012E+01
                                                                                        WEIGHTED ERROR SUM =   .5898E+01
ERRORS
   .5940E-05   .1389E-04   .2251E+02   .5987E-05   .1937E-03
WEIGHTED ERRORS
   .5940E+00   .9722E+00  0.           .2395E+01   .1937E+01

                                                   ITERATION NUMBER   5 COMPLETED
 ITERATION TERMINATING, ERROR WITHIN  .001000  BOUND.
```

```
CONFIDENCE LEVELS FOR NEXT TO LAST ITERATION
    (DIMENSIONAL)

AC                                     3  BY  3
              .4742E-02  0.             0.
              .1515E-01   .1104E-01     0.
             0.          0.             0.
BC                                     3  BY  5
              .1529E-02  0.             0.             0.             .7219E-03
              .4719E-01  0.             0.             0.             .2837E-02
             0.          0.             0.             0.            0.

    (NON-DIMENSIONAL)
AC                                     3  BY  3
              .7959E-03  0.             0.
              .2538E-04   .1471E+00     0.
             0.          0.             0.
BC                                     3  BY  5
              .2566E-03  0.             0.             0.             .6942E-02
              .7902E-04  0.             0.             0.             .2722E-03
             0.          0.             0.             0.            0.
```

AIRCRAFT B CHECK CASE 09/17/74

FINAL VALUES MACH = .429 ALPHA = 7.86 PARAM = 5.0000 CG = .260

DIMENSIONAL DERIVATIVES / SEC / SEC**2

	ALFA	Q	V	DE	DC	DC1	DC2	DELTA-O
N	.450226	-1.000000*	0.000000*	.051967	0.000000*	0.000000*	0.000000*	-.084289
M	-3.192019	-.500318	0.000000*	-6.263662	0.000000*	0.000000*	0.000000*	.092063
A	-15.668030*	-0.000000*	0.000000*	-8.353920*	0.000000*	0.000000*	0.000000*	2.393650*

NON-DIMENSIONAL DERIVATIVES / DEG (ROTARY /RAD)

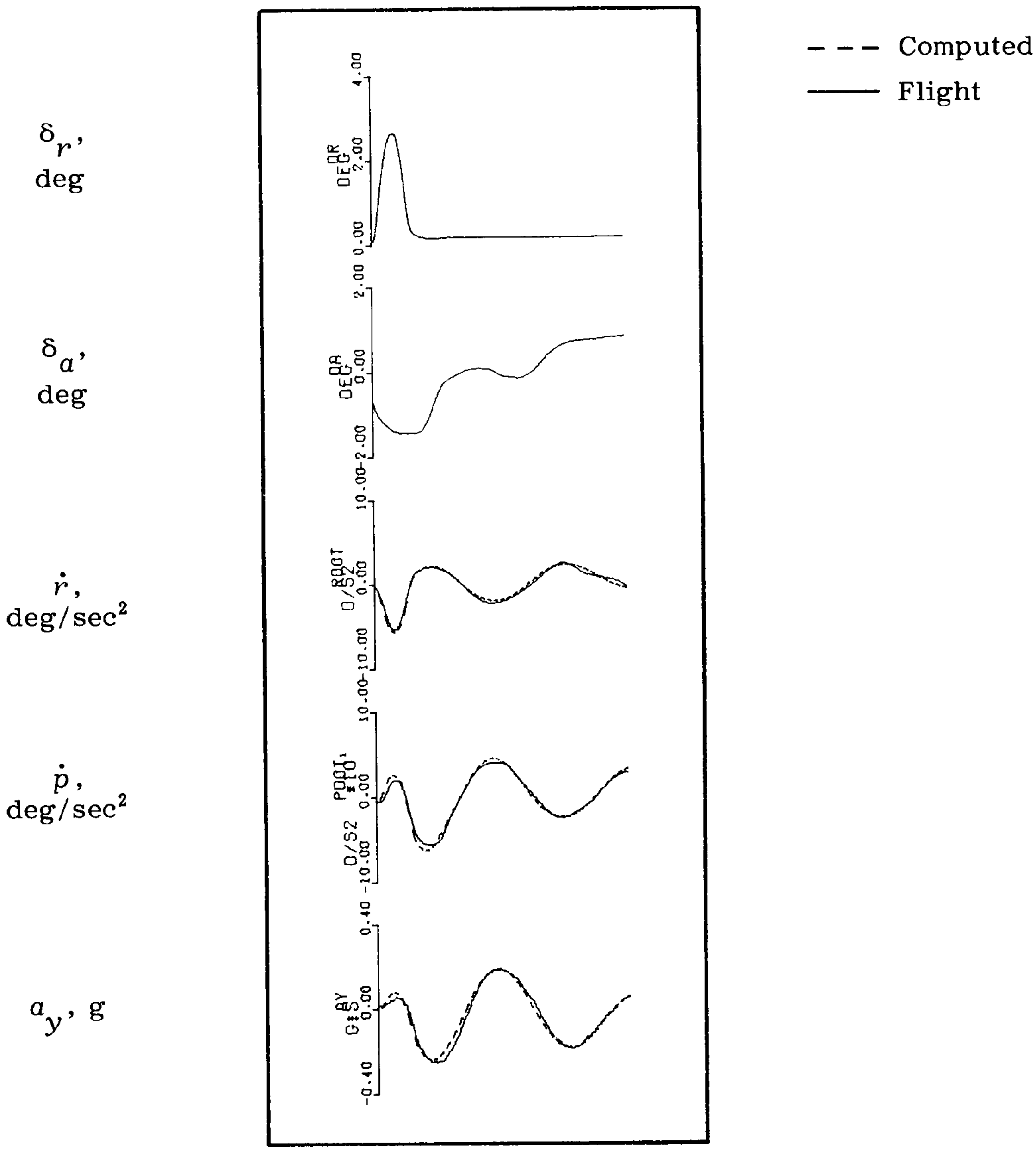
	ALFA	Q	V	DE	DC	DC1	DC2	DELTA-O
CN	.075562	0.000000*	0.000000*	.008722	0.000000*	0.000000*	0.000000*	-.810524
CM	-.005345	-6.665883	0.000000*	-.010489	0.000000*	0.000000*	0.000000*	.008833
CA	-.006333*	-0.000000*	0.000000*	-.003377*	0.000000*	0.000000*	0.000000*	.055437*

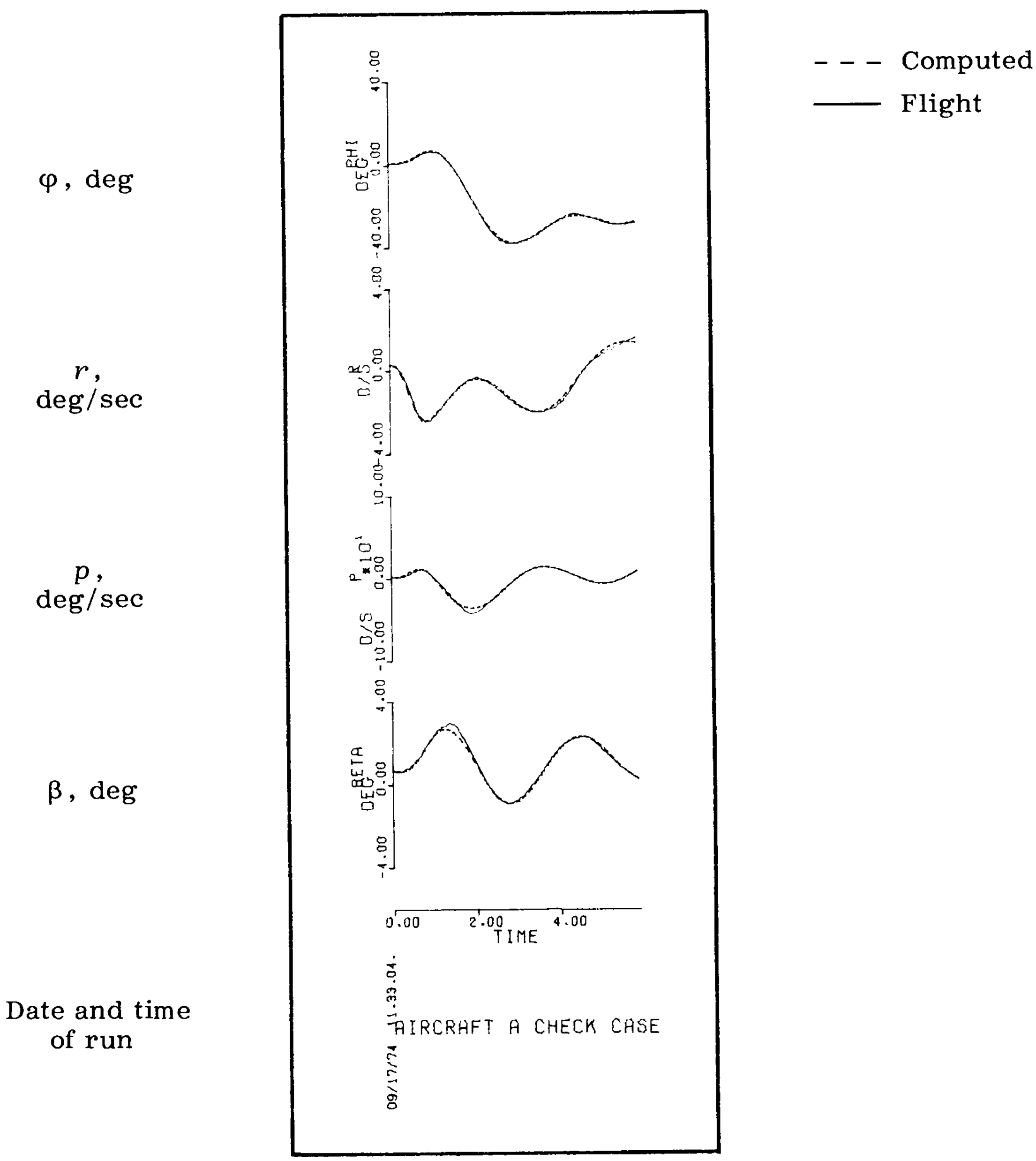
(*) INDICATES DERIVATIVE HELD FIXED DURING MATCH

```
VARIABLE BIAS    .1012E+01
FINAL DIMENSIONAL MATRICES
A                               4  BY  4
           -.4502E+00   .1000E+01  -0.          .2210E-02
           -.3192E+01  -.5003E+00   0.         0.
            .1567E+02  0.          -0.         -.3216E+02
           0.           .9916E+00   0.         0.
B                               4  BY  5
           -.5197E-01  -0.          -0.         -0.          .8429E-01
           -.6264E+01   0.           0.          0.          .9206E-01
            .8354E+01  -0.          -0.         -0.         -.2394E+01
          -0.           .1000E+01  -0.         -0.           .1517E-02

DEGREES          AN
VARIABLE BIAS    .1012E+01
                                                   WEIGHTED ERROR SUM =   .5898E+01
ERRORS
   .5945E-05   .1390E-04   .2251E+02   .5985E-05   .1937E-03
WEIGHTED ERRORS
   .5945E+00   .9728E+00  0.           .2394E+01   .1937E+01
                                                       ERRORS
    219.31      6.69       5.92       5.90       5.90       5.90
```

Two sample plots from the MMLE program are shown. The plots as produced by the automatic plotter are shown within the heavy lines. Explanatory material is included to aid the user in implementing the program. Each plot is presented in two parts to avoid loss of detail from a large reduction. The title on each plot corresponds to the title on the output listing.




- - - Computed
——— Flight
φ, deg
r, deg/sec
p, deg/sec
β, deg
Date and time of run
PHI DEG
40.00
0.00
-40.00
R D/S
4.00
0.00
-4.00
P D/S ×10¹
10.00
0.00
-10.00
BETA DEG
4.00
0.00
-4.00
0.00
2.00
4.00
TIME
09/17/74 11.33.04.
AIRCRAFT A CHECK CASE

$\bar{q}$, lb/sq ft

M

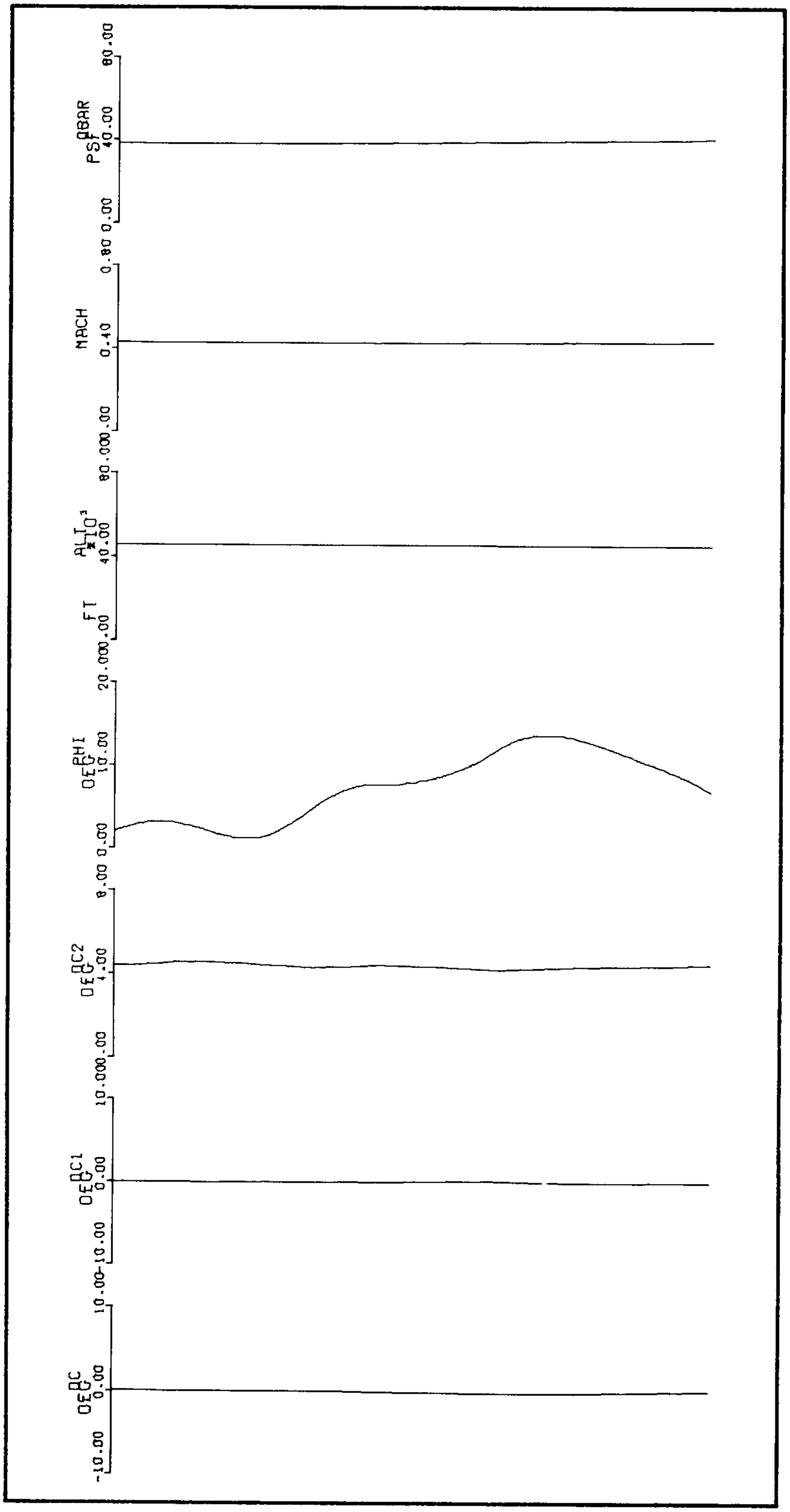
Altitude, ft

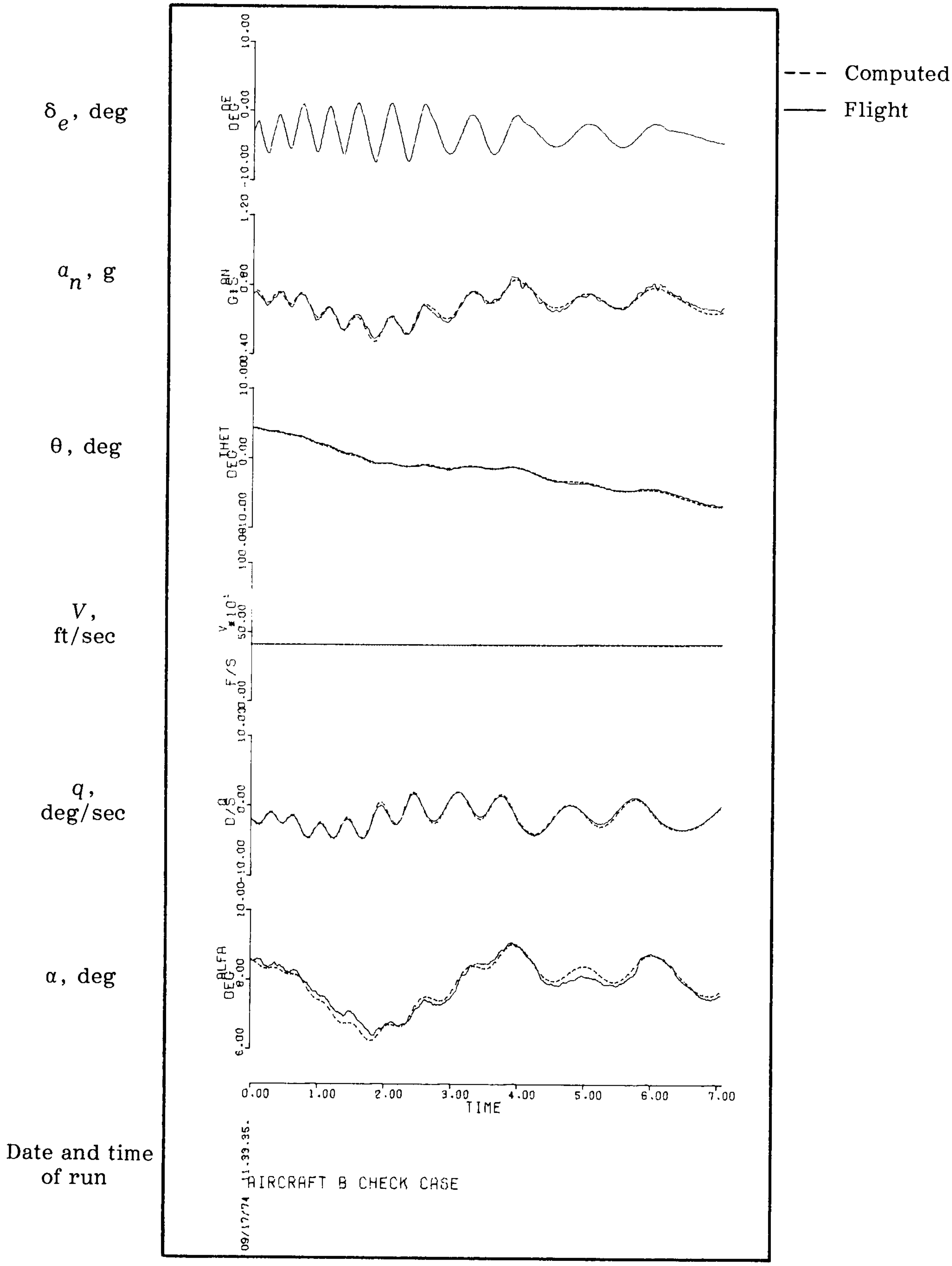
φ, deg

δ_{c_2}, deg

δ_{c_1}, deg

δ_c, deg




Computed
Flight
δ_e, deg
a_n, g
θ, deg
V, ft/sec
q, deg/sec
α, deg
Date and time of run
DE DEG
AN G'S
THET DEG
V F/S
Q D/S
ALFA DEG
TIME
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
AIRCRAFT B CHECK CASE
09/17/74 11.33.35.

APPENDIX C

SETUP PROGRAM AND SUBROUTINES

Listings of the main program and the subroutines used in the SETUP program are presented together with supplementary information.

MAIN PROGRAM SETUP

Description: The main SETUP program sets several defaults and then reads the option cards to determine whether it is to read an input tape, punch a card deck, write an output tape, or perform any combination of these operations. It then directs the execution of the assigned tasks for each case.

Programing notes: As in the MMLE program, the program statement is needed on CDC 6000/7000 systems. On an IBM 360/370 system, DD cards perform this function. Cards 590 to 730 are concerned solely with setting the default values for DELTA as defined in the input description (p. 30).

Program listing:

```
      PROGRAM SETUP(INPUT,PUNCH,OUTPUT,TAPE4,TAPE15,TAPE1=INPUT,
     -      TAPE2=PUNCH,TAPE3=OUTPUT)
      COMMON /ALLDIM/ MAX,MIX
      COMMON /OPTION/ TAPE,DECK,READ
      COMMON /FLCOND/ ALPHA,THETA,Q,V,MACH,IX,IY,IZ,IXZ,W,PHI,CG,KIAS,
     -      ALT,LONG,PARAM,FLT,CASE,AVG,DELTA,ST,ET,DETRIM
      REAL MACH,IX,IY,IZ,IXZ,KIAS,AVG(40)
      INTEGER ST(4),ET(4),FLT,CASE
      LOGICAL TAPE,DECK,READ,LONG,LATR,DELTA(4),LATDEL(4),LONDEL(4),DEL
      NAMELIST /COND/ LONG,LATR,FLT,CASE,ALPHA,THETA,Q,V,MACH,W,IX,IY,
     -      IZ,IXZ,KIAS,ALT,CG,PARAM,DELTA,PHI,DETRIM
      DATA WRT/4HWRIT/,PNC/4HPUNC/,RD/4HREAD/,START/4HSTAR/
      MAX=5
      REWIND 15
      DO 10 I=1,4
      LONDEL(I)=.FALSE.
   10 LATDEL(I)=.FALSE.
      TAPE=.FALSE.
      DECK=.FALSE.
      READ=.FALSE.
      DETRIM=0.
      PARAM=0.
      CG=999.
      IXZ=0.
      ALT=0.
      KIAS=0.
      THETA=0.
      PHI=0.
      FLT=0
      CASE=0
      LONG=.FALSE.
C
C     READ OPTIONS
C
   20 READ (1,1000) OPTN
      IF(OPTN.EQ.START) GO TO 50
      IF(OPTN.NE.WRT) GO TO 40
      TAPE=.TRUE.
      WRITE(3,2001)
   30 READ=.TRUE.
      WRITE(3,2000)
      GO TO 20
   40 IF(OPTN.EQ.RD) GO TO 30
      IF(OPTN.NE.PNC) GO TO 20
      DECK=.TRUE.
      WRITE(3,2002)
      GO TO 20
   50 IF(DECK) CALL SETIN
      IF(READ) CALL RDSET
C
C     CASE LOOP
C
  100 READ (1,1001) ST,ET
      IF(ST(1).LT.0) GO TO 200
      LATR=.FALSE.
      DO 110 I=1,4
  110 DELTA(I)=.FALSE.
```

```
      READ (1,COND)
      IF(LATR) LONG=.FALSE.
      DEL=DELTA(1).OR.DELTA(2).OR.DELTA(3).OR.DELTA(4)
      IF(LONG) GO TO 150
      IF(.NOT.DEL) GO TO 130
      DO 120 I=1,4
  120 LATDEL(I)=DELTA(I)
      GO TO 190
  130 DO 140 I=1,4
  140 DELTA(I)=LATDEL(I)
      GO TO 190
  150 IF(.NOT.DEL) GO TO 170
      DO 160 I=1,4
  160 LONDEL(I)=DELTA(I)
      GO TO 190
  170 DO 180 I=1,4
  180 DELTA(I)=LONDEL(I)
 190  WRITE(3,2003)FLT,CASE,ST,ET,LONG
      IF(READ) CALL TAPERD
      IF(DECK) CALL PNCH
      GO TO 100
 1000 FORMAT(A4)
 1001 FORMAT(2(3I2,I3,1X))
 2000 FORMAT(18H0TAPE WILL BE READ)
 2001 FORMAT(25H0MLE TAPE WILL BE WRITTEN)
 2002 FORMAT(25H0MLE DECK WILL BE PUNCHED)
 2003 FORMAT(1H1,20X,6HFLIGHT,I3,5X,4HCASE,I4,5X,4HTIME,4I4,4H  TO,
     -       4I4,5X,14HLONGITUDINAL? ,L1)
  200 STOP
      END
```

SUBROUTINE SETIN

Description: Subroutine SETIN initializes all information needed to punch the MMLE program deck. It sets several defaults and reads in the values desired. It also calls WINDIN to input predicted derivatives and COND1 to make any other input required by the user.

Subroutine listing:

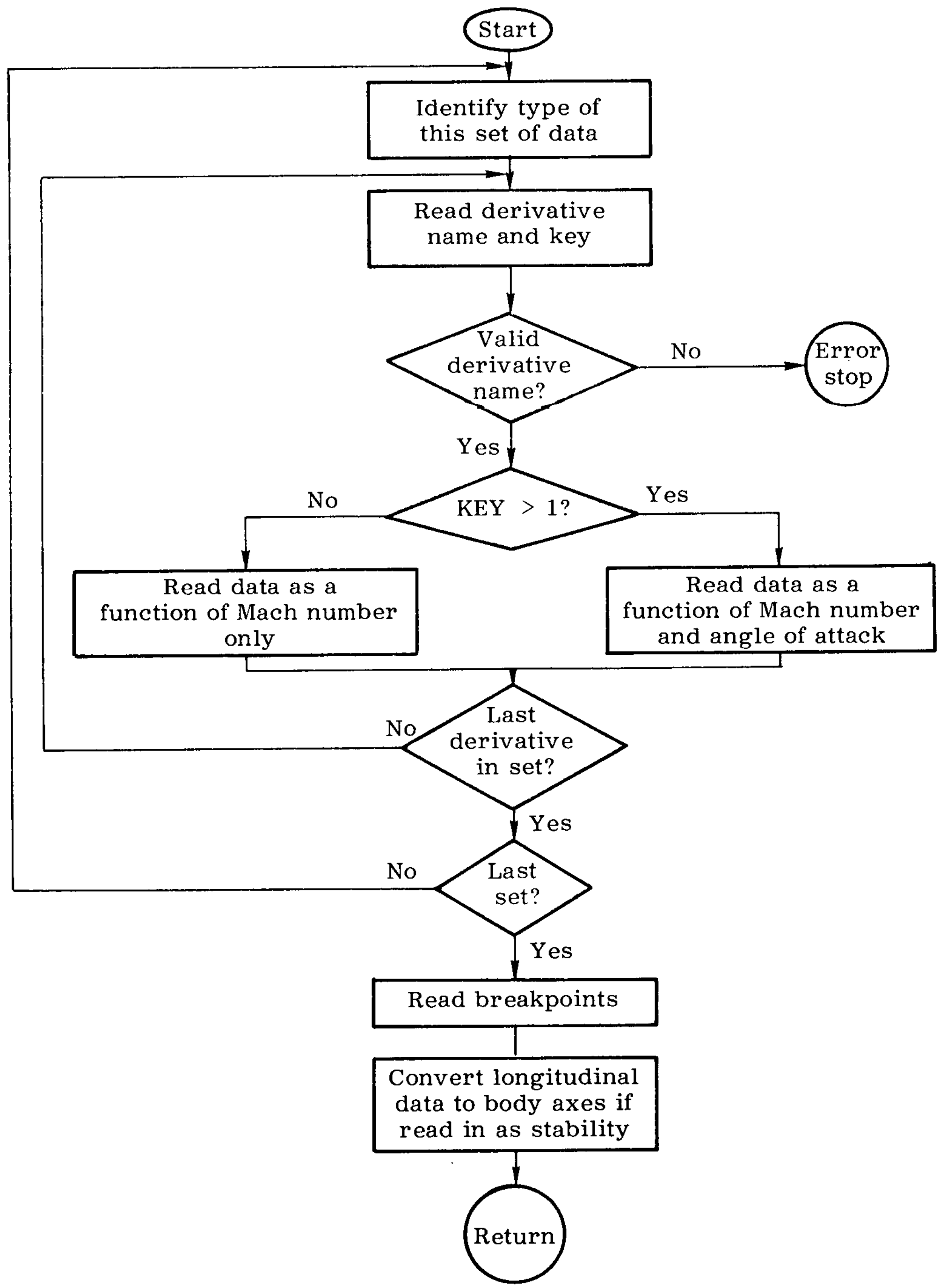
```
      SUBROUTINE SETIN
      COMMON /COM/ MZLA,MZLO,S,SPAN,CBAR,CGLA,CGLO,METRIC,D1LO,
     -     D1LA,VEH,APRALA,APRBLA,APRALO,APRBLO,WMLA,WMLO,PUNCH,CORECT,
     -     XALF,XB,ZB,XAN,ZAX,XAY,ZAY,SPS,DLA,DLO
      COMMON /DATAWT/ NBP,NMBP,NABP,DATA
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG
      REAL DATA(3000),D1LO(7),D1LA(7),ABP(16),MBP(16),BP(8),VEH(2),
     -     APRALA(5,4),APRALO(5,4),APRBLA(5,8),APRBLO(5,8)
      LOGICAL METRIC,LONG(8),LATR(8),RAD,DEG,PUNCH,CORECT,BODY,STAB,
     -     LAT,LON,DLA,DLO
      NAMELIST /WIND/ NABP,NMBP,NBP,S,SPAN,CBAR,CGLA,CGLO,DEG,RAD,
     -     METRIC,LONG,LATR,MZLO,MZLA,NCLO,NCLA,WMLO,WMLA,PUNCH,XALF,
     -     XAN,ZAX,XAY,ZAY,SPS,XB,ZB,BODY,STAB
C
C     DEFAULTS
      SPS=0.
      XB=0.
      ZB=0.
      XAY=0.
      ZAY=0.
      XAN=0.
      ZAX=0.
      XALF=0.
      CORECT=.FALSE.
      CGLA=.25
      CGLO=.25
      MZLA=5
      MZLO=5
      PUNCH=.FALSE.
      METRIC=.FALSE.
      BODY=.FALSE.
      DLA=.FALSE.
      DLO=.FALSE.
      WMLA=-99999.
      WMLO=-99999.
      RAD=.FALSE.
      DO 5 I=1,3000
    5 DATA(I)=0.
      DO 10 I=1,8
      BP(I)=0.
      LONG(I)=.TRUE.
   10 LATR(I)=.FALSE.
      NBP=1
      NABP=1
      NMBP=1
      LON=.FALSE.
      LAT=.FALSE.
      READ (1,WIND)
      IF(ABS(XB)+ABS(ZB)+ABS(XALF)+ABS(XAN)+ABS(ZAX)+ABS(XAY)+ABS(ZAY)
     -     .NE. 0.) CORECT=.TRUE.
      DO 40 I=1,NBP
      IF(.NOT.LATR(I)) GO TO 30
      LONG(I)=.FALSE.
   30 IF(LONG(I)) GO TO 35
      LAT=.TRUE.
      GO TO 40
   35 LON=.TRUE.
```

```
   40 CONTINUE                                                          SETI 570
      READ (1,1000) VEH                                                 SETI 580
      IF(LAT) READ (1,1001) D1LA                                        SETI 590
      IF(LON) READ (1,1001) D1LO                                        SETI 600
      IF(D1LA(1)+D1LA(2)+D1LA(3)+D1LA(4)+D1LA(5).GT.0.) DLA=.TRUE.      SETI 610
      IF(D1LO(1)+D1LO(2)+D1LO(3)+D1LO(4)+D1LO(5).GT.0.) DLO=.TRUE.      SETI 620
      IF(WMLA.LT.0.) GO TO 50                                           SETI 630
      CALL LOAD1(APRALA)                                                SETI 640
      CALL LOAD1(APRBLA)                                                SETI 650
   50 IF(WMLO.LT.0.) GO TO 60                                           SETI 660
      CALL LOAD1(APRALO)                                                SETI 670
      CALL LOAD1(APRBLO)                                                SETI 680
   60 WRITE(3,2000)VEH,CGLA,CGLO,RAD                                    SETI 690
      CALL WINDIN(DATA,NBP,NMBP,NABP,BODY,.TRUE.,RAD)                   SETI 700
      CALL COND1                                                        SETI 710
 1000 FORMAT(2A4)                                                       SETI 720
 1001 FORMAT(7F10.4)                                                    SETI 730
 2000 FORMAT(1H1,2A4,5X,27HWIND TUNNEL DATA.  REF CG =,F5.3,7H (LAT),,  SETI 740
     -      F5.3,23H (LONG)     PER RADIAN? ,L1)                        SETI 750
      RETURN                                                            SETI 760
      END                                                               SETI 770
```

SUBROUTINE WINDIN

Description: Subroutine WINDIN reads in predicted derivatives, converting longitudinal data from the stability axes to the body axes if required.

Flow chart:



Programing notes: The loop from cards 770 to 1000 is written in a more expanded form than necessary to improve its efficiency.

Subroutine listing:

```
      SUBROUTINE WINDIN(DATA,NBP,NMBP,NABP,BODY,PRINT,RAD)               WIND   0
C                                                                        WIND  10
C     READS IN WIND TUNNEL DATA                                          WIND  20
C                                                                        WIND  30
C     DATA IS DIMENSIONED (NBP,NMBP,NABP,NCMAX) WITH THE LAST 2          WIND  40
C     DIMENSIONS HANDLED IN FORTRAN FOR COMPILERS LIMITED TO 3-D         WIND  50
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG                    WIND  60
      REAL DATA(NBP,NMBP,1),ABP(16),MBP(16),BP(8),DER(21,3)              WIND  70
      LOGICAL LONG(8),BODY,PRINT,RAD                                     WIND  80
      INTEGER NNABP(21)                                                  WIND  90
      DATA DER/3HCYB,3HCLB,3HCNB,3HCLP,3HCNP,3HCLR,3HCNR,4HCYDA,4HCLDA,  WIND 100
     -     4HCNDA,4HCYDR,4HCLDR,4HCNDR,4HCYD1,4HCLD1,4HCND1,4HCYD2,      WIND 110
     -     4HCLD2,4HCND2,1H ,1H ,                                        WIND 120
     -     3HCLA,3HCMA,3HCDA,3HCMQ,3HCLV,3HCMV,3HCDV,4HCLDE,4HCMDE,      WIND 130
     -     4HCDDE,4HCLDC,4HCMDC,4HCDDC,4HCLD1,4HCMD1,4HCDD1,4HCLD2,      WIND 140
     -     4HCMD2,4HCDD2,2HCL,2HCD,                                      WIND 150
     -     3HCNA,3HCMA,3HCAA,3HCMQ,3HCNV,3HCMV,3HCAV,4HCNDE,4HCMDE,      WIND 160
     -     4HCADE,4HCNDC,4HCMDC,4HCADC,4HCND1,4HCMD1,4HCAD1,4HCND2,      WIND 170
     -     4HCMD2,4HCAD2,2HCN,2HCA/                                      WIND 180
      NCMAX=21                                                           WIND 190
C     READ NBP SETS OF WIND TUNNEL DATA                                  WIND 200
      DO 200 L=1,NBP                                                     WIND 210
      NC=NCLA                                                            WIND 220
      LL=1                                                               WIND 230
      IF(.NOT.LONG(L)) GO TO 5                                           WIND 240
      NC=NCLO                                                            WIND 250
      LL=2                                                               WIND 260
      IF(BODY) LL=3                                                      WIND 270
    5 IF(NC.EQ.0) GO TO 200                                              WIND 280
      DO 100 II=1,NC                                                     WIND 290
C     READ AND IDENTIFY DERIVATIVE NAME                                  WIND 300
      READ (1,1002) DERIV,N                                              WIND 310
      IF(PRINT) WRITE(3,2000)DERIV                                       WIND 320
      DO 10 I=1,NCMAX                                                    WIND 330
      IF(DERIV.EQ.DER(I,LL)) GO TO 20                                    WIND 340
   10 CONTINUE                                                           WIND 350
      WRITE(3,2001)DERIV                                                 WIND 360
      STOP                                                               WIND 370
C     INPUT DATA AS FUNCTION OF MACH AND ALPHA OR MACH ONLY              WIND 380
   20 K2=I*NABP                                                          WIND 390
      K1=K2-NABP+1                                                       WIND 400
      IF(N.LE.1) GO TO 40                                                WIND 410
      DO 30 J=1,NMBP                                                     WIND 420
      READ (1,1001) (DATA(L,J,K),K=K1,K2)                                WIND 430
   30 IF(PRINT) WRITE(3,2002)(DATA(L,J,K),K=K1,K2)                       WIND 440
      GO TO 60                                                           WIND 450
   40 READ (1,1001) (DATA(L,J,K1),J=1,NMBP)                              WIND 460
      IF(PRINT) WRITE(3,2002)(DATA(L,J,K1),J=1,NMBP)                     WIND 470
      DO 50 J=1,NMBP                                                     WIND 480
      DO 50 K=K1,K2                                                      WIND 490
   50 DATA(L,J,K)=DATA(L,J,K1)                                           WIND 500
   60 IF(.NOT.RAD.OR.(I.GT.3.AND.I.LT.8).OR.I.GT.19) GO TO 100           WIND 510
      DO 70 J=1,NMBP                                                     WIND 520
      DO 70 K=K1,K2                                                      WIND 530
   70 DATA(L,J,K)=DATA(L,J,K)/57.2958                                    WIND 540
  100 CONTINUE                                                           WIND 550
  200 CONTINUE                                                           WIND 560
```

```
C
C     READ BREAKPOINTS
C
      READ (1,1001) (ABP(J),J=1,NABP)
      IF(PRINT) WRITE(3,2003)(ABP(J),J=1,NABP)
      READ (1,1001)  (MBP(J),J=1,NMBP)
      IF(PRINT) WRITE(3,2004)(MBP(J),J=1,NMBP)
      READ  (1,1001) (BP(J),J=1,8)
      IF(PRINT) WRITE(3,2005)(BP(J),J=1,NBP)
      IF(BODY)  RETURN
C     CONVERT STABILITY TO BODY AXES
      DO 210 I=1,21
  210 NNABP(I)=I*NABP
      DO 300 K=1,NABP
      DO 220 I=1,21
  220 NNABP(I)=NNABP(I)+1
      SA=SIN(ABP(K)/57.2958)
      CA=COS(ABP(K)/57.2958)
      DO 300 L=1,NBP
      IF(.NOT.LONG(L)) GO TO 300
      DO 280 J=1,NMBP
      TEMP=DATA(L,J,NNABP(19))*CA+DATA(L,J,NNABP(20))*SA
      DATA(L,J,NNABP(20))=DATA(L,J,NNABP(20))*CA-DATA(L,J,NNABP(19))*SA
      DATA(L,J,NNABP(19))=TEMP
      TEMP=DATA(L,J,K)*CA+DATA(L,J,NNABP(2))*SA+DATA(L,J,NNABP(20))
     -     /57.2958
      DATA(L,J,NNABP(2))=DATA(L,J,NNABP(2))*CA-DATA(L,J,K)*SA-
     -     DATA(L,J,NNABP(19))/57.2958
      DATA(L,J,K)=TEMP
      TEMP=DATA(L,J,NNABP( 4))*CA+DATA(L,J,NNABP( 6))*SA
      DATA(L,J,NNABP( 6))=DATA(L,J,NNABP( 6))*CA-DATA(L,J,NNABP( 4))*SA
      DATA(L,J,NNABP( 4))=TEMP
      TEMP=DATA(L,J,NNABP( 7))*CA+DATA(L,J,NNABP( 9))*SA
      DATA(L,J,NNABP( 9))=DATA(L,J,NNABP( 9))*CA-DATA(L,J,NNABP( 7))*SA
      DATA(L,J,NNABP( 7))=TEMP
      TEMP=DATA(L,J,NNABP(10))*CA+DATA(L,J,NNABP(12))*SA
      DATA(L,J,NNABP(12))=DATA(L,J,NNABP(12))*CA-DATA(L,J,NNABP(10))*SA
      DATA(L,J,NNABP(10))=TEMP
      TEMP=DATA(L,J,NNABP(13))*CA+DATA(L,J,NNABP(15))*SA
      DATA(L,J,NNABP(15))=DATA(L,J,NNABP(15))*CA-DATA(L,J,NNABP(13))*SA
      DATA(L,J,NNABP(13))=TEMP
      TEMP=DATA(L,J,NNABP(16))*CA+DATA(L,J,NNABP(18))*SA
      DATA(L,J,NNABP(18))=DATA(L,J,NNABP(18))*CA-DATA(L,J,NNABP(16))*SA
  280 DATA(L,J,NNABP(16))=TEMP
  300 CONTINUE
 1001 FORMAT(8F10.4)
 1002 FORMAT(A4,4X,I2)
 2000 FORMAT(1X,A8)
 2001 FORMAT(1X,A8,49HIS NOT A VALID DERIVATIVE NAME FOR THIS TYPE CASE)
 2002 FORMAT(5X,10E13.5)
 2003 FORMAT(18H ALPHA BREAKPOINTS/5X,10F13.5)
 2004 FORMAT(17H MACH BREAKPOINTS/5X,10F13.5)
 2005 FORMAT(18H PARAM BREAKPOINTS/5X,10F13.5)
      RETURN
      END
```

SUBROUTINE TAPERD

Description: Subroutine TAPERD supervises the reading of the input tape and obtains averages of the channels read in. It also writes the output file if desired. It calls TAPEIN, the user-supplied input routine, to do the actual reading of the input tape.

Subroutine listing:

```
      SUBROUTINE TAPERD
      COMMON /OPTION/ TAPE,DECK,READ
      COMMON /FLCOND/ ALPHA,THETA,Q,V,MACH,IX,IY,IZ,IXZ,W,PHI,CG,KIAS,
     -      ALT,LONG,PARAM,FLT,CASE,AVG,DELTA,ST,ET,DETRIM
      REAL MACH,IX,IY,IZ,IXZ,KIAS,AVG(40),DATA(40,100)
      LOGICAL TAPE,DECK,READ,DELTA(4)
      INTEGER ST(4),ET(4),TIME(4,100),JST(4)
      NFRAME=100
      DO 10 I=1,40
   10 AVG(I)=0.
      NPT=0
   20 CALL TAPEIN(DATA,TIME,NFRAME,ST,ET)
      NFR=IABS(NFRAME)
      DO 100 I=1,NFR
      IF(TAPE) WRITE (4) (TIME(J,I),J=1,4),(DATA(J,I),J=1,25)
      DO 30 J=1,40
   30 AVG(J)=AVG(J)+DATA(J,I)
      NPT=NPT+1
      IF(NPT.NE.1) GO TO 100
      DO 40 J=1,4
   40 JST(J)=TIME(J,I)
  100 CONTINUE
      IF(NFRAME.GT.0) GO TO 20
  110 ANPT=NPT
      DO 120 I=1,40
  120 AVG(I)=AVG(I)/ANPT
      WRITE(3,2000)NPT,JST,(TIME(J,NFR),J=1,4),AVG
 2000 FORMAT(1H0,I5,22H POINTS IN CASE. TIMES,4I4,4H  TO,4I4/
     -      17H0CHANNEL AVERAGES/(10X,10F12.4))
      RETURN
      END
```

SUBROUTINE PNCH

Description: Subroutine PNCH dimensionalizes coefficients and punches the MMLE card deck.

Programing notes: Through card 540, this subroutine contains some computations and initializations used in all cases. Then cards 590 to 980 contain the lateral-directional dimensionalization and computations; cards 1030 to 1390 contain this information for the longitudinal cases. The remaining cards control the punching of the output deck.

Subroutine listing:

```
      SUBROUTINE PNCH                                                    PNCH   0
      COMMON /FLCOND/ ALPHA,THETA,Q,V,MACH,IX,IY,IZ,IXZ,W,PHI,CG,KIAS,   PNCH  10
     -     ALT,LONG,PARAM,FLT,CASE,AVG,DELTA,ST,ET,DETRIM                PNCH  20
      COMMON /COM/ MZLA,MZLO,S,SPAN,CBAR,CGLA,CGLO,METRIC,D1LO,          PNCH  30
     -     D1LA,VEH,APRALA,APRBLA,APRALO,APRBLO,WMLA,WMLO,PUNCH,CORECT,  PNCH  40
     -     XALF,XB,ZB,XAN,ZAX,XAY,ZAY,SPS,DLA,DLO                        PNCH  50
      COMMON /DATAWT/ NBP,NMBP,NABP,DATA                                 PNCH  60
      REAL MACH,IX,IY,IZ,IXZ,KIAS,AVG(40),DATA(3000),D1LO(7),D1LA(7),    PNCH  70
     -     VEH(2),APRALA(5,4),APRALO(5,4),APRBLA(5,8),APRBLO(5,8),       PNCH  80
     -     A(5,4),B(5,5),BB(5,5),X(21),MASS                              PNCH  90
      INTEGER ST(4),ET(4),FLT,CASE                                       PNCH 100
      LOGICAL LONG,DELTA(4),METRIC,PUNCH,CORECT,DLA,DLO                  PNCH 110
      DATA ALAB,BLAB,BBLAB,ALAT,ALON/1HA,1HB,2HBB,4HLATR,4HLONG/         PNCH 120
      A(5,1)=4.                                                          PNCH 130
      A(5,2)=4.                                                          PNCH 140
      A(5,3)=ALAB                                                        PNCH 150
      B(5,1)=4.                                                          PNCH 160
      B(5,2)=5.                                                          PNCH 170
      B(5,3)=BLAB                                                        PNCH 180
      CALL AZOT(A)                                                       PNCH 190
      CALL AZOT(B)                                                       PNCH 200
      CALL AMAKE(BB,B)                                                   PNCH 210
      BB(5,3)=BBLAB                                                      PNCH 220
      BB(1,5)=1.                                                         PNCH 230
      BB(2,5)=1.                                                         PNCH 240
      BB(4,5)=1.                                                         PNCH 250
      CALL COND                                                          PNCH 260
      TIMESC=.5                                                          PNCH 270
      IT=((ET(1)-ST(1))*3600+(ET(2)-ST(2))*60+ET(3)-ST(3))*1000+         PNCH 280
     -     ET(4)-ST(4)                                                   PNCH 290
      IF(IT.GT.12500) TIMESC=1.                                          PNCH 300
      IF(IT.GT.25000) TIMESC=2.                                          PNCH 310
      CALL INTERP(DATA,NBP,NMBP,NABP,X)                                  PNCH 320
      RAD=57.2958                                                        PNCH 330
      CGFLT=CG                                                           PNCH 340
      IF(CG.NE.999.) GO TO 7                                             PNCH 350
 3007 FORMAT(44HOCG NOT SPECIFIED. DEFAULTED TO WIND TUNNEL.)            PNCH 360
      WRITE(3,3007)                                                      PNCH 370
      CGFLT=CGLA                                                         PNCH 380
      IF(LONG) CGFLT=CGLO                                                PNCH 390
    7 DCG=0.                                                             PNCH 400
      ALPR=ALPHA/RAD                                                     PNCH 410
      THETR=THETA/RAD                                                    PNCH 420
      PHIR=PHI/RAD                                                       PNCH 430
      STH=SIN(THETR)                                                     PNCH 440
      CT=COS(THETR)                                                      PNCH 450
      CP=COS(PHIR)                                                       PNCH 460
      G=32.172                                                           PNCH 470
      IF(METRIC) G=9.80665                                               PNCH 480
      MASS=W/G                                                           PNCH 490
      QS=Q*S                                                             PNCH 500
      QSOMV=QS/(MASS*V)                                                  PNCH 510
      WRITE(2,3000)VEH,FLT,CASE,MACH,ALPHA,PARAM,W,IX,IY,IZ,IXZ,Q,V,     PNCH 520
     -     PUNCH,TIMESC                                                  PNCH 530
      WRITE(3,2000)ALPHA,MACH,Q,V,CGFLT,PARAM                            PNCH 540
      IF(LONG) GO TO 100                                                 PNCH 550
C                                                                        PNCH 560
```

```
C     LATERAL
C
      WMAPR=ABS(WMLA)
      IF(.NOT.CORECT) GO TO 10
      DCG=CGFLT-CGLA
      XBC=XB
      XAYC=XAY
      IF(XB.NE.0.) XBC=XBC+DCG*CBAR
      IF(XAY.NE.0.) XAYC=XAYC+DCG*CBAR
      WRITE(2,3001)XBC,ZB,XAYC,ZAY
   10 TYPE=ALAT
      BB(3,5)=1.
      QSOMV=QSOMV*RAD
      QSB=QS*SPAN*RAD
      QSBIX=QSB/IX
      QSBIZ=QSB/IZ
      B2V=SPAN/(2.*V*RAD)
      QSBVIX=QSBIX*B2V
      QSBVIZ=QSBIZ*B2V
      DCG=DCG*CBAR/SPAN
      A(1,1)=QSOMV*X(1)
      A(2,1)=QSBIX*X(2)
      A(3,1)=QSBIZ*(X(3)+DCG*X(1))
      A(1,2)=SIN(ALPR)
      A(2,2)=QSBVIX*X(4)
      A(3,2)=QSBVIZ*X(5)
      A(4,2)=1.
      A(1,3)=-COS(ALPR)
      A(2,3)=QSBVIX*X(6)
      A(3,3)=QSBVIZ*X(7)
      A(4,3)=CP*STH/CT
      A(1,4)=CP*CT*G/V
      DO 20 I=1,4
      J=3*I+5
      B(1,I)=QSOMV*X(J)
      B(2,I)=QSBIX*X(J+1)
      B(3,I)=QSBIZ*(X(J+2)+DCG*X(J))
      IF(.NOT.DELTA(I)) GO TO 20
      BB(1,I)=1.
      BB(2,I)=1.
      BB(3,I)=1.
   20 CONTINUE
      GO TO 200
C
C     LONGITUDINAL
C
  100 WMAPR=ABS(WMLO)
      IF(.NOT.CORECT) GO TO 110
      DCG=CGFLT-CGLO
      XALFC=XALF
      XANC=XAN
      IF(XALFC.NE.0.) XALFC=XALFC+DCG*CBAR
      IF(XANC.NE.0.) XANC=XANC+DCG*CBAR
      WRITE(2,3003)XALFC,XANC,ZAX
  110 TYPE=ALON
      WRITE(2,3002)
      QSOM=QSOMV*V
```

```
      QSCIY=QS*CBAR/IY                                                  PNCH1140
      V2=2./V                                                           PNCH1150
      QSCVIY=QSCIY*CBAR/(2.*V)                                          PNCH1160
      A(1,1)=-QSOMV*X(1)*RAD                                            PNCH1170
      A(2,1)=QSCIY*(X(2)*RAD-DCG*A(1,1)/QSOMV)                          PNCH1180
      A(3,1)=-QSOM*X(3)*RAD                                             PNCH1190
      A(1,2)=1.                                                         PNCH1200
      A(2,2)=QSCVIY*X(4)                                                PNCH1210
      A(4,2)=CP                                                         PNCH1220
      A(1,3)=-QSOMV*V2*X(5)                                             PNCH1230
      A(2,3)=QSCIY*V2*X(6)                                              PNCH1240
      A(3,3)=-QSOM*V2*X(7)                                              PNCH1250
      A(1,4)=-STH*CP*G/V                                                PNCH1260
      A(3,4)=-CT*G                                                      PNCH1270
      DO 130 I=1,4                                                      PNCH1280
      J=3*I+5                                                           PNCH1290
      B(1,I)=-QSOMV*X(J)*RAD                                            PNCH1300
      B(2,I)=QSCIY*(X(J+1)*RAD-DCG*B(1,I)/QSOMV)                        PNCH1310
      B(3,I)=-QSOM*X(J+2)*RAD                                           PNCH1320
      IF(.NOT.DELTA(I)) GO TO 130                                       PNCH1330
      BB(1,I)=1.                                                        PNCH1340
      BB(2,I)=1.                                                        PNCH1350
  130 CONTINUE                                                          PNCH1360
      B(1,5)=-QSOMV*X(20)-(A(1,1)*ALPHA+B(1,1)*DETRIM)/RAD+CP*CT*G/V    PNCH1370
      B(2,5)=-(A(2,1)*ALPHA+B(2,1)*DETRIM)/RAD                          PNCH1380
      B(3,5)=-QSOM*X(21)-(A(3,1)*ALPHA+B(3,1)*DETRIM)/RAD               PNCH1390
  200 IF(WMAPR.EQ.99999.) WMAPR=0.                                      PNCH1400
      WRITE(2,3004)WMAPR,ALPHA,MACH,CGFLT,PARAM,TYPE,S,SPAN,CBAR,SPS,   PNCH1410
     1            ST,ET                                                 PNCH1420
      CALL PMAT(A)                                                      PNCH1430
      CALL PMAT(B)                                                      PNCH1440
      IF(DELTA(1).OR.DELTA(2).OR.DELTA(3).OR.DELTA(4)) CALL PMAT(BB)    PNCH1450
      IF(LONG) GO TO 210                                                PNCH1460
      IF(DLA) WRITE(2,3005)MZLA,D1LA                                    PNCH1470
      IF(WMLA.LT.0.) GO TO 250                                          PNCH1480
      CALL PMAT1(APRALA)                                                PNCH1490
      CALL PMAT1(APRBLA)                                                PNCH1500
      GO TO 250                                                         PNCH1510
  210 IF(DLO) WRITE(2,3005)MZLO,D1LO                                    PNCH1520
      IF(WMLO.LT.0.) GO TO 250                                          PNCH1530
      CALL PMAT1(APRALO)                                                PNCH1540
      CALL PMAT1(APRBLO)                                                PNCH1550
  250 WRITE(2,3006)                                                     PNCH1560
      RETURN                                                            PNCH1570
 2000 FORMAT(8H0ALPHA =,F6.2,9H   MACH =,F5.3,6H   Q =,F7.1,6H   V =,   PNCH1580
     -       F7.1,7H   CG =,F5.3,10H   PARAM =,F10.4)                   PNCH1590
 3000 FORMAT(2A4,6X,6HFLIGHT,I4,6H  CASE,I4,6X,5HMACH=,F5.3,            PNCH1600
     -       8H  ALPHA=,F6.2,8H  PARAM=,F7.2/15H $INPUT GROSWT=,F7.0,   PNCH1610
     -       6H  ,IX=,F7.0,6H  ,IY=,F7.0,6H  ,IZ=,F7.0,7H  ,IXZ=,F7.1,1H,/PNCH1620
     -       3H Q=,F6.1,5H  ,V=,F6.1,9H  ,PUNCH=,L1,10H  ,TIMESC=,F3.1,  PNCH1630
     -       10H  ,BOTH=T,)                                             PNCH1640
 3001 FORMAT(4H XB=,F6.2,6H  ,ZB=,F6.2,7H  ,XAY=,F6.2,7H  ,ZAY=,F6.2,   PNCH1650
     -       1H,)                                                       PNCH1660
 3002 FORMAT(15H ZMAX(3)=1000.,)                                        PNCH1670
 3003 FORMAT(6H XALF=,F6.2,7H  ,XAN=,F6.2,7H  ,ZAX=,F6.2,1H,)           PNCH1680
 3004 FORMAT(7H WMAPR=,E8.2,9H  ,ALPHA=,F6.2,8H  ,MACH=,F5.3,6H  ,CG=,  PNCH1690
     -       F5.3,9H  ,PARAM=,F10.4,1H,/1X,A4,7H=T,  S=,F5.0,           PNCH1700
```

```
     -       8H   ,SPAN=,F6.2,8H   ,CBAR=,F6.2,7H   ,SPS=,F4.0,7H,  $END/     PNCH1710
     -       2(3I2,I3,1X))                                                     PNCH1720
 3005 FORMAT(2HD1,7X,I1/7F10.1)                                                PNCH1730
 3006 FORMAT(7HENDCASE)                                                        PNCH1740
      END                                                                      PNCH1750
```

SUBROUTINE INTERP

Description: Subroutine INTERP interpolates predicted derivative data tables to obtain the nondimensional derivatives for a particular flight condition.

Programing notes: The subroutine first brackets the Mach number and angle of attack of the flight condition between breakpoints of the predicted data; it also selects the correct set of predicted data depending on the value of PARAM. The interpolation is divided into four sections. The interpolation occurs in one of the four sections on the basis of how many Mach and angle-of-attack breakpoints are specified. If only one breakpoint is specified, the required code changes slightly, because there are not two points to interpolate between.

Subroutine listing:

```
      SUBROUTINE INTERP(DATA,NBP,NMBP,NABP,X)
C
C     INTERPOLATES WIND TUNNEL DATA
C
      COMMON /FLCOND/ ALPHA,THETA,Q,V,MACH,IX,IY,IZ,IXZ,W,PHI,CG,KIAS,
     -      ALT,LONG,PARAM,FLT,CASE,AVG,DELTA,ST,ET,DETRIM
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONGWT
      REAL MACH,IX,IY,IZ,IXZ,KIAS,AVG(40),DATA(NBP,NMBP,1),ABP(16),
     -      MBP(16),BP(8),X(21)
      INTEGER ST(4),ET(4),FLT,CASE
      LOGICAL DELTA(4),LONG,LONGWT(8),XORF
C     FIND CORRECT SET OF DATA
      L=1
      DO 60 II=1,NBP
      XORF=(LONG.AND.LONGWT(II)).OR.(.NOT.LONG.AND..NOT.LONGWT(II))
   60 IF((PARAM.EQ.BP(II).OR.PARAM*BP(II).EQ.0.) .AND. XORF) L=II
C     BRACKET ALPHA
      IF(NABP.EQ.1) GO TO 50
      DO 40 J=2,NABP
      IF(ALPHA.GT. ABP(J)) GO TO 40
      EAP=(ALPHA-ABP(J-1))/(ABP(J)-ABP(J-1))
      IF(EAP.LT.0.) EAP=0.
      GO TO 50
   40 CONTINUE
      J=NABP
      EAP=1.
C     BRACKET MACH NUMBER
   50 IF(NMBP.EQ.1) GO TO 100
      DO 20 I=2,NMBP
      IF(MACH.GT. MBP(I)) GO TO 20
      EMN=(MACH-MBP(I-1))/(MBP(I)-MBP(I-1))
      IF(EMN.LT.0.) EMN=0.
      GO TO 30
   20 CONTINUE
      I=NMBP
      EMN=1.
   30 IM1=I-1
      IF(NABP.EQ.1) GO TO 120
C     INTERPOLATE DATA
      DO 90 K=1,NCMAX
      JK=(K-1)*NABP+J
      JM1K=JK-1
      PA=(DATA(L,I,JK)-DATA(L,IM1,JK))*EMN+DATA(L,IM1,JK)
      PB=(DATA(L,I,JM1K)-DATA(L,IM1,JM1K))*EMN+DATA(L,IM1,JM1K)
   90 X(K)=(PA-PB)*EAP+PB
      GO TO 200
  100 IF(NABP.EQ.1) GO TO 140
C     INTERPOLATE IF ONLY 1 MACH BREAKPOINT
      DO 110 K=1,NCMAX
      JK=(K-1)*NABP+J
      JM1K=JK-1
  110 X(K)=DATA(L,1,JM1K)+EAP*(DATA(L,1,JK)-DATA(L,1,JM1K))
      GO TO 200
C     IF ONLY 1 ALPHA BREAKPOINT
  120 DO 130 K=1,NCMAX
  130 X(K)=(DATA(L,I,K)-DATA(L,IM1,K))*EMN+DATA(L,IM1,K)
      GO TO 200
```

```
C     IF ONLY 1 ALPHA AND 1 MACH BREAKPOINT
  140 DO 150 K=1,NCMAX
  150 X(K)=DATA(L,1,K)
  200 RETURN
      END
```

SUBROUTINE PMAT

Description: Subroutine PMAT punches a matrix on cards in an 8F10.5 format.

Subroutine listing:

```
      SUBROUTINE PMAT(A)
C     PUNCHES A MATRIX
      COMMON /ALLDIM/ MAX,MIX
      REAL A(1)
      II=A(MAX)
      JJ=A(2*MAX)
      WRITE(2,1000)A(3*MAX),II,JJ
      KE=(JJ-1)*MAX
      DO 20 I=1,II
      KEND=I+KE
   20 WRITE(2,1001)(A(K),K=I,KEND,MAX)
      CALL ASPIT(A)
 1000 FORMAT(A4,4X,I2,I10)
 1001 FORMAT(8F10.5)
      RETURN
      END
```

SUBROUTINE PMAT1

Description: Subroutine PMAT1 punches a matrix on cards in an 8E10.3 format.

Programing notes: This subroutine is needed in addition to PMAT because the APRA and APRB matrices may contain large values but do not need as many significant figures as other matrices.

Subroutine listing:

```
      SUBROUTINE PMAT1(A)
C     PUNCHES A MATRIX IN E FORMAT
      COMMON /ALLDIM/ MAX,MIX
      REAL A(1)
      II=A(MAX)
      JJ=A(2*MAX)
      WRITE(2,1000)A(3*MAX),II,JJ
      KE=(JJ-1)*MAX
      DO 20 I=1,II
      KEND=I+KE
   20 WRITE(2,1001)(A(K),K=I,KEND,MAX)
 1000 FORMAT(A4,4X,I2,I10)
 1001 FORMAT(8E10.3)
      RETURN
      END
```

SUBROUTINE RDSET

Description: Subroutine RDSET is user supplied; the subroutine listed here is a sample. This subroutine should do any initialization or input required before calling subroutine TAPEIN.

Subroutine listing:

```
      SUBROUTINE RDSET
C
C     THIS SUBROUTINE SHOULD INCLUDE ANY INITIALIZATION DESIRED FOR
C     READING THE INPUT TAPE, FOR INSTANCE SPECIFYING CHANNEL NUMBERS.
C     DATA SHOULD BE PASSED TO SUBROUTINE TAPEIN WITH LABELLED COMMON
C          BLOCK /TAPDAT/
C     THIS SAMPLE VERSION READS THE NUMBER OF WORDS ON THE INPUT TAPE
C     AND THE CHANNEL NUMBERS OFTHE SIGNALS NEEDED
C
      COMMON /TAPDAT/ NWORD,ICHAN
      INTEGER ICHAN(40)
      READ (1,1000) NWORD
      READ (1,1000) ICHAN
      WRITE(3,2000)NWORD,ICHAN
 1000 FORMAT(16I5)
 2000 FORMAT(20H0INPUT FILE CONTAINS,I5,22H DATA WORDS PER RECORD/
     1    9H CHANNELS/(10X,20I5))
      RETURN
      END
```

SUBROUTINE TAPEIN

Description: Subroutine TAPEIN is user supplied; the subroutine listed here is a sample. This subroutine should be written to read data in the form available for a particular flight program. The comment cards and sample program illustrate the conventions required for interface with the rest of the program.

Subroutine listing:

```
      SUBROUTINE TAPEIN(DATA,TIME,NFRAME,ST,ET)                         TAPE   0
C                                                                       TAPE  10
C     THIS SUBROUTINE SHOULD READ THE INPUT TAPE AND PLACE UP TO        TAPE  20
C     NFRAME FRAMES IN THE TIME INTERVAL BETWEEN ST AND ET (START TIME   TAPE  30
C     AND END TIME) INTO THE ARRAYS TIME AND DATA                       TAPE  40
C     THE TIME ARRAY SHOULD CONTAIN HOURS,MINUTES,SECONDS,MILLISECONDS  TAPE  50
C     THE DATA ARRAY SHOULD CONTAIN THE DATA CHANNELS IN THE ORDER TO   TAPE  60
C     WRITTEN ON THE OUTPUT TAPE                                        TAPE  70
C     WHEN THE LAST TIME IN THE REQUESTED INTERVAL IS FOUND,            TAPE  80
C     NFRAME SHOULD BE SET TC MINUS THE NUMBER OF FRAMES OF CATA        TAPE  90
C     BEING RETURNED                                                    TAPE 100
C                                                                       TAPE 110
C     THIS SAMPLE VERSION READS AN UNFORMATTED TAPE AND PICKS THE       TAPE 120
C     SIGNALS DESIRED FROM THE CHANNELS SPECIFIED IN SUBROUTINE RDSET   TAPE 130
C                                                                       TAPE 140
      COMMON /TAPDAT/ NWORD,ICHAN                                       TAPE 150
      INTEGER ST(4),ET(4),TIME(4,100),ICHAN(40),IT(4)                   TAPE 160
      REAL DATA(40,100),RECORD(150)                                     TAPE 170
      IST=ST(4)+1000*(ST(3)+60*ST(2)+3600*ST(1))                        TAPE 180
      IET=ET(4)+1000*(ET(3)+60*ET(2)+3600*ET(1))                        TAPE 190
      I=0                                                               TAPE 200
   10 READ (15)IT,(RECORD(J),J=1,NWORD)                                 TAPE 210
      ITM=IT(4)+1000*(IT(3)+60*IT(2)+3600*IT(1))                        TAPE 220
      IF(ITM.LT.IST) GO TO 10                                           TAPE 230
   20 I=I+1                                                             TAPE 240
      DO 30 J=1,4                                                       TAPE 250
   30 TIME(J,I)=IT(J)                                                   TAPE 260
      DO 40 J=1,40                                                      TAPE 270
      DATA(J,I)=0.                                                      TAPE 280
      IF(ICHAN(J).EQ.0) GO TO 40                                        TAPE 290
      DATA(J,I)=RECORD(ICHAN(J))                                        TAPE 300
   40 CONTINUE                                                          TAPE 310
      IF(I.GE.NFRAME) RETURN                                            TAPE 320
      IF(ITM.GE.IET) GO TO 100                                          TAPE 330
      READ (15)IT,(RECORD(J),J=1,NWORD)                                 TAPE 340
      ITM=IT(4)+1000*(IT(3)+60*IT(2)+3600*IT(1))                        TAPE 350
      GO TO 20                                                          TAPE 360
  100 NFRAME=-I                                                         TAPE 370
      RETURN                                                            TAPE 380
      END                                                               TAPE 390
```

SUBROUTINE COND1

Description: Subroutine COND1 is user supplied, and is described by the comment cards.

Subroutine listing:

```
      SUBROUTINE COND1
C
C     THIS SUBROUTINE SHOULD INCLUDE ANY INITIALIZATION NEEDED
C     FOR SUBROUTINE COND TO DETERMINE THE FLIGHT CONDITION
C     TYPICAL ITEMS INCLUDED HERE MIGHT BE TABLES OF INERTIAS AS A
C     FUNCTION OF GROSS WEIGHT
C     ANY DATA MAY BE PASSED TO SUBROUTINE COND THROUGH A LABELLED
C     COMMON BLOCK /TABLE/
C     SUBROUTINE SUPPLIED IS A NULL SUBROUTINE
C
      RETURN
      END
```

SUBROUTINE COND

Description: Subroutine COND is user supplied. It automatically obtains the flight condition from the channel averages computed by TAPERD. The subroutine listed illustrates the method of doing this.

Subroutine listing:

```
      SUBROUTINE COND
C
C     THIS SUBROUTINE SHOULD SPECIFY THE FLIGHT CONDITION AND OTHER
C     PARAMETERS NOT READ IN THROUGH NAMELIST /COND/
C     AVG CONTAINS THE AVERAGE VALUES OF EACH CHANNEL READ OFF THE INPUT
C     TAPE IF THERE WAS ONE READ
C     THE USER MAY CHOOSE TO USE THESE AVERAGE VALUES FOR THE FLIGHT
C     CONDITION INSTEAD OF READING IT IN
C     FOR INSTANCE, IF ALPHA IS TO BE OBTAINED FROM THE CHANNEL AVERAGE
C     THE STATEMENT
C     ALPHA=AVG(1)
C     WOULD BE INCLUDED HERE
C     THE SEVERAL EXTRA CHANNELS AVAILABLE MAY BE USED TO OBTAIN
C     FUEL WEIGHTS OR OTHER QUANTITIES NEEDED TO COMPUTE THE INERTIAS
C
C     THE SUBROUTINE SUPPLIED OBTAINS ALPHA,THETA,PHI,DETRIM,Q,V,AND
C     MACH FROM SIGNAL AVERAGES AND COMPUTES Q AND V FROM ALTITUDE
C     AND KIAS(KNOTS INDICATED AIRSPEED) IF THESE ARE MORE READILY
C     AVAILABLE (INDICATED BY A NON-ZERO VALUE OF KIAS)
C
      COMMON /OPTION/ TAPE,DECK,READ
      COMMON /FLCOND/ ALPHA,THETA,Q,V,MACH,IX,IY,IZ,IXZ,W,PHI,CG,KIAS,
     -      ALT,LONG,PARAM,FLT,CASE,AVG,DELTA,ST,ET,DETRIM
      REAL MACH,IX,IY,IZ,IXZ,KIAS,AVG(40)
      INTEGER ST(4),ET(4),FLT,CASE
      LOGICAL DELTA(4),LONG,TAPE,DECK,READ
      IF(.NOT.READ) GO TO 10
      ALPHA=AVG(1)
      THETA=AVG(4)
      PHI=AVG(12)
      DETRIM=AVG(8)
      Q=AVG(15)
      V=AVG(3)
      MACH=AVG(14)
   10 IF(KIAS.EQ.0.) RETURN
      Q=(KIAS*.0582)**2
      DALT=ALT*.001
      V=1.688*KIAS*EXP(DALT*(.01375+.0000975*DALT))
      RETURN
      END
```

SUBROUTINE LOAD1

Description: Subroutine LOAD1 reads a matrix from cards.

Subroutine listing:

```
      SUBROUTINE LOAD1(A)                                               LOAD   0
      COMMON /ALLDIM/ MAX,MIX                                           LOAD  10
      REAL A(1)                                                         LOAD  20
      MAX3=3*MAX                                                        LOAD  30
      READ (1,1000) A(MAX3),II,JJ                                       LOAD  40
      A(MAX)=II                                                         LOAD  50
      A(2*MAX)=JJ                                                       LOAD  60
      KE=(JJ-1)*MAX                                                     LOAD  70
      DO 10 I=1,II                                                      LOAD  80
      KEND=I+KE                                                         LOAD  90
   10 READ (1,1001) (A(K),K=I,KEND,MAX)                                 LOAD 100
 1000 FORMAT(A4,4X,I2,I10)                                              LOAD 110
 1001 FORMAT(8F10.4)                                                    LOAD 120
      RETURN                                                            LOAD 130
      END                                                               LOAD 140
```

SUBROUTINES ASPIT, AMAKE, AND AZOT

Subroutines ASPIT, AMAKE, and AZOT are identical to those used in the MMLE program.

APPENDIX D

SAMPLE CASE FOR THE SETUP PROGRAM

This appendix presents a sample check case for the SETUP program.

INPUT CARDS

```
PUNCH DECK
START
 $WIND NMBP=2,NARP=2,NCLO=8,LONG(1)=T,SPAN=15.,CBAR=6.,S=100.,$END
SAMPLE
 0.
CL        2
 .1         .5
0.          .4
CD        2
 .05        .1
  .07       .12
CLA       1
 .07        .065
CDA       1
 .01        .015
CMA       1
 -.005      -.006
CLDE      1
 .01        .01
CMDE      1
 -.009      -.011
CMQ       1
 -5.        -5.
 .3         .7
 .0         5.
0.
102051000 102100000 SAMPLE CASE 1
 $COND IX=300.,IY=2000.,IZ=2000.,IXZ=10.,W=2500.,LONG=T,
 FLT=1,CASE=1,Q=50.,V=450.,ALPHA=4.,MACH=.5,$END
102512000 102522000 SAMPLE CASE 2
 $COND CASE=2,Q=60.,V=500.,ALPHA=3.,MACH=.55,$END
-1
```

OUTPUT LISTING

```
SAMPLE        WIND TUNNEL DATA.  REF CG = .250 (LAT), .250 (LONG)     PER RADIAN? F
CL
        .10000E+00    .50000E+00
       0.             .40000E+00
CD
        .50000E-01    .10000E+00
        .70000E-01    .12000E+00
CLA
        .70000E-01    .65000E-01
CDA
        .10000E-01    .15000E-01
CMA
       -.50000E-02   -.60000E-02
CLDE
        .10000E-01    .10000E-01
CMDE
       -.96000E-02   -.11000E-01
CMQ
       -.50000E+01   -.50000E+01
ALPHA BREAKPOINTS
            .30000        .70000
MACH BREAKPOINTS
           0.00000       5.00000
PARAM BREAKPOINTS
           0.00000
```

```
                 FLIGHT  1      CASE   1      TIME  10  20  51   0  TO  10  21   0   0      LONGITUDINAL? T

CG NOT SPECIFIED. DEFAULTED TO WIND TUNNEL.

ALPHA =   4.00   MACH = .500   Q =     50.0   V =   450.0   CG = .250   PARAM =      0.0000
A                                      4  BY  4
            -.5841E+00    .1000E+01 -0.         -0.
            -.4383E+01  -.5000E+00  0.          0.
            -.3970E+01  0.          -0.         -.3217E+02
            0.           .1000E+01  0.          0.
B                                      4  BY  5
            -.8192E-01 -0.          -0.         -0.          .4204E-01
            -.7907E+01  0.           0.          0.          .3060E+00
             .4504E+00 -0.          -0.         -0.         -.5900E+01
            0.          0.           0.          0.          0.
```

```
                 FLIGHT  1     CASE   2     TIME  10  25  12   0  TO  10  25  22   0      LONGITUDINAL? T

CG NOT SPECIFIED. DEFAULTED TO WIND TUNNEL.

ALPHA =   3.00   MACH = .550    Q =     60.0   V =   500.0   CG = .250   PARAM =     0.0000
A                                        4  BY  4
            -.6304E+00    .1000E+01 -0.          -0.
            -.5270E+01  -.5400E+00  0.            0.
            -.5065E+01  0.          -0.          -.3217E+02
            0.           .1000E+01  0.            0.
B                                        4  BY  5
            -.8847E-01 -0.          -0.          -0.           .2165E-01
            -.9509E+01  0.           0.           0.           .2759E+00
             .5405E+00 -0.          -0.          -0.         -.7164E+01
            0.          0.           0.           0.          0.
```

PUNCHED CARD OUTPUT LISTING

```
SAMPLE         FLIGHT    1   CASE    1       MACH= .500  ALPHA=  4.00  PARAM=   0.00
 $INPUT GROSWT=  2500.   ,IX=    300.  ,IY=  2000.  ,IZ=  2000.  ,IXZ=    10.0,
 Q=  50.0  ,V= 450.0   ,PUNCH=F   ,TIMESC= .5   ,BOTH=T,
 ZMAX(3)=1000.,
 WMAPR=0.          ,ALPHA=  4.00   ,MACH= .500   ,CG= .250   ,PARAM=     0.0000,
 LONG=T,  S= 100.   ,SPAN= 15.00   ,CBAR=  6.00   ,SPS=  0.,  $END
102051   0 1021 0  0
A        4          4
    -.58412    1.00000   -0.00000   -0.00000
   -4.38313    -.50000    0.00000    0.00000
   -3.97020    0.00000   -0.00000  -32.17200
    0.00000    1.00000    0.00000    0.00000
B        4          5
    -.08192   -0.00000   -0.00000   -0.00000     .04204
   -7.90682    0.00000    0.00000    0.00000     .30600
     .45040   -0.00000   -0.00000   -0.00000   -5.90024
    0.00000    0.00000    0.00000    0.00000    0.00000
ENDCASE
SAMPLE         FLIGHT    1   CASE    2       MACH= .550  ALPHA=  3.00  PARAM=   0.00
 $INPUT GROSWT=  2500.   ,IX=    300.  ,IY=  2000.  ,IZ=  2000.  ,IXZ=    10.0,
 Q=  60.0  ,V= 500.0   ,PUNCH=F   ,TIMESC= .5   ,BOTH=T,
 ZMAX(3)=1000.,
 WMAPR=0.          ,ALPHA=  3.00   ,MACH= .550   ,CG= .250   ,PARAM=     0.0000,
 LONG=T,  S= 100.   ,SPAN= 15.00   ,CBAR=  6.00   ,SPS=  0.,  $END
102512   0 102522  0
A        4          4
    -.63044    1.00000   -0.00000   -0.00000
   -5.27007    -.54000    0.00000    0.00000
   -5.06514    0.00000   -0.00000  -32.17200
    0.00000    1.00000    0.00000    0.00000
B        4          5
    -.08847   -0.00000   -0.00000   -0.00000     .02165
   -9.50881    0.00000    0.00000    0.00000     .27594
     .54048   -0.00000   -0.00000   -0.00000   -7.16407
    0.00000    0.00000    0.00000    0.00000    0.00000
ENDCASE
```

APPENDIX E

SUMARY PROGRAM AND SUBROUTINES

Listings of the main program and the subroutines used in the SUMARY program are presented together with supplemental information.

MAIN PROGRAM SUMARY

Description: The main program SUMARY sets defaults, reads the NAMELIST, and initializes variables.

Program listing:

```
      PROGRAM SUMARY(INPUT,OUTPUT,TAPE69,TAPE1=INPUT,TAPE3=OUTPUT)
C
C     SUMMARY PLOT PROGRAM FOR MMLE DATA
C
      COMMON /ALLDIM/ MAX,MIX
      COMMON /LINCOM/ HGT
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG
      COMMON /CGCOR/ SHIFT,CGLA,CGLO,COB
      COMMON /NBPS/ NMBP,NABP,NBP,NPARAM
      COMMON /INS/ NPLOT,WTPLOT
      COMMON /SUMDAT/ YLOC,XSKIP,ALEN,ASCAL2,YSTEP,AMIN,TABLAB,FDATA,
     -      FDATAC,TITLE
      COMMON /PSCL/ CRFACT,IWT1,IWT2,YLEN2,II,NPARM
      REAL TITLE(20),ABP(16),BP(8),MBP(16),DATA(3000),FDATA(5000),
     -      FDATAC(5000),BUF(1024),FDAT(200),FDATC(200),ALFS(200),
     -      TABLAB(2),MLAB(2),PLAB(2)
      LOGICAL PRINT,LONG(8),LATR(8),DEG,RAD,BODY,STAB,SHIFT,WTPLOT
      DATA MLAB/4HMACH,1H /,PLAB/4HPARA,1HM/
      NAMELIST /WIND/ NBP,NABP,NMBP,NCLA,NCLO,RAD,DEG,BODY,STAB,
     -      LONG,LATR,PRINT,CGLA,CGLO,NPARAM,SHIFT,WTPLOT,CRFACT,
     -      AMIN,AMAX,ASCALE,YLEN,XDIST,CBAR,SPAN
      NBUF=1024
      MAX=4
      READ (1,1000) TITLE
      WRITE(3,2000)TITLE
      HGT=.07
      SHIFT=.FALSE.
      CBAR=0.
      SPAN=1.E+50
      NPARAM=0
      NCLA=0
      NCLO=0
      NBP=1
      CGLA=.25
      CGLO=.25
      NABP=1
      NMBP=1
      PRINT=.FALSE.
      DO 5 I=1,3000
    5 DATA(I)=0.
      DO 10 I=1,8
      LATR(I)=.FALSE.
      LONG(I)=.TRUE.
   10 BP(I)=0.
      RAD=.FALSE.
      STAB=.TRUE.
      BODY=.FALSE.
      WTPLOT=.TRUE.
      CRFACT=1.
      AMIN=0.
      AMAX=12.
      ASCALE=1.
      YLEN=10.
      XDIST=10.
      READ (1,WIND)
      NPARM=NPARAM
      COB=CBAR/SPAN
```

```
      YLEN2=YLEN/2.
      YLOC=0.
      ASCAL2=ASCALE*2.
      ALEN=(AMAX-AMIN)/ASCAL2
      XSKIP=ALEN+XDIST/2.
      YSTEP=YLEN2+1.
      DO 20 I=1,8
   20 IF(LATR(I)) LONG(I)=.FALSE.
C     READ WIND TUNNEL DATA
      CALL WINDIN(DATA,NBP,NMBP,NABP,BODY,PRINT,RAD)
      IF(SHIFT) WRITE(3,2001)CGLA,CGLO
      IF(CRFACT.NE.0.) WRITE(3,2002)CRFACT
      IWT1=1
      IWT2=1
      DO 15 I=1,NABP
      IF(ABP(I).LT.AMIN) IWT1=I+1
   15 IF(ABP(I).LE.AMAX) IWT2=I
      NCMX=NCMAX+2
      ND=NMBP*2
      TABLAB(1)=MLAB(1)
      TABLAB(2)=MLAB(2)
      IF(NPARAM.LE.0) GO TO 25
      ND=NPARAM*2
      TABLAB(1)=PLAB(1)
      TABLAB(2)=PLAB(2)
   25 ND2=ND/2
C     READ FLIGHT DATA
      CALL FLIGHT(NCMX,ND,FDATA,FDATAC)
      CALL PLOTS(BUF,NBUF,69)
      CALL FACTOR(.787402)
      CALL PLOT(0.,.5,-3)
C     READ PLOTTING INSTRUCTIONS
   30 CALL INSTR
      IF(NPLOT.LE.0) GO TO 50
C     MAKE PLOTS
      DO 40 II=1,NPLOT
   40 CALL SUMPLT(FDAT,FDATC,ALFS,ND2,DATA,NBP,NMBP,NABP)
      GO TO 30
   50 CALL PLOT(0.,0.,999)
 1000 FORMAT(20A4)
 2000 FORMAT(51H1MMLE SUMMARY PLOTTING PROGRAM     ****    1 MAY 1974/
     -     1H0,20X,20A4)
 2001 FORMAT(55H0CNB AND CMA WILL BE CORRECTED TO THE WIND TUNNEL REFER,
     -     8HENCE CGS,F10.3,7H (LATR),F10.3,7H (LONG))
 2002 FORMAT(48H0CONFIDENCE LEVELS WILL BE PLOTTED MULTIPLIED BY,F5.1)
      STOP
      END
```

SUBROUTINE FLIGHT

Description: Subroutine FLIGHT reads and sorts flight data.

Programing notes: Data are stored in the arrays FDATA and FDATAC. The FDATA array contains derivative values, and the FDATAC array contains confidence levels. Note that the sign of the X and Z coefficients is changed for longitudinal data to agree with the more common N and A (axial) coefficients. The flight C_{m_α} and C_{n_β} are shifted to the wind-tunnel reference center of gravity if SHIFT = T. LONLOC and LATLOC give the positions of data in the A and B matrices considered as vectors.

Subroutine listing:

```
      SUBROUTINE FLIGHT(NCMX,ND,FDATA,FDATAC)
C     READS FLIGHT DATA AND SORTS BY MACH OR PARAM
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG
      COMMON /CGCOR/ SHIFT,CGLA,CGLO,COB
      COMMON /CASES/ NCASE
      COMMON /NBPS/ NMBP,NABP,NBP,NPARAM
      REAL FDATA(NCMX,ND,1),FDATAC(NCMX,ND,1),ABP(16),MBP(16),BP(8),
     -     A(16),B(32),AC(16),BC(32),MACH,TITL(9)
      LOGICAL LONG(8),SHIFT
      INTEGER NCASE(32),LONLCC(21),LATLOC(19)
      DATA PLT/4HPLOT/,ALAT/4HLATR/,LONLOC/1,2,3,6,9,10,11,1,2,3,5,6,7,
     -     9,10,11,13,14,15,17,18/,LATLOC/1,2,3,6,7,10,11,1,2,3,5,6,7,
     -     9,10,11,13,14,15/
      ND2=ND/2
      DO 10 I=1,32
   10 NCASE(I)=0
   20 READ (1,1000) TYPE,TITL,MACH,ALPHA,PARAM,CG
      IF(TYPE.EQ.PLT) RETURN
      WRITE(3,2000)TYPE,TITL,MACH,ALPHA,PARAM,CG
C     FLIGHT DATA IS STORED AS FDATA(COEFFICIENT,GROUP,CASE)
C          WHERE GROUP=INDEX IF LONG, OR INDEX+ND/2 IF LATR
C          AND INDEX IDENTIFIES EITHER THE MACH OR (IF NPARAM.GT.0)
C          THE EXTRA PARAMETER
      CALL LOAD1(A )
      CALL LOAD1(B )
      CALL LOAD1(AC)
      CALL LOAD1(BC)
      INDEX=2
      IF(ND2.LT.2) GO TO 60
      IF(NPARAM.GT.0) GO TO 40
      DO 30 INDEX=2,NMBP
      IF(MACH.LT.(MBP(INDEX)+MBP(INDEX-1))*.5) GO TO 60
   30 CONTINUE
      INDEX=NMBP+1
      GO TO 60
   40 DO 50 INDEX=2,NPARAM
      IF(PARAM.LT.(BP(INDEX)+BP(INDEX-1))*.5) GO TO 60
   50 CONTINUE
      INDEX=NPARAM+1
   60 INDEX=INDEX-1
      IF(TYPE.EQ.ALAT) GO TO 110
C     LONGITUDINAL - CHANGE SIGN OF X AND Z DERIVATIVES
      DO 70 I=1,11,2
   70 A(I)=-A(I)
      DO 80 I=1,19,2
   80 B(I)=-B(I)
      NCAS=NCASE(INDEX)+1
      IF(SHIFT) A(2)=A(2)+(CGLO-CG)*A(1)
      DO 100 I=1,21
      IF(I.GE.8) GO TO 90
      FDATA(I,INDEX,NCAS)=A(LONLOC(I))
      FDATAC(I,INDEX,NCAS)=AC(LONLOC(I))
      GO TO 100
   90 FDATA(I,INDEX,NCAS)=B(LONLOC(I))
      FDATAC(I,INDEX,NCAS)=BC(LONLOC(I))
  100 CONTINUE
      GO TO 150
```

```
  110 INDEX=INDEX+ND2
      NCAS=NCASE(INDEX)+1
      IF(SHIFT) A(3)=A(3)+(CGLA-CG)*COB*A(1)
      DO 130 I=1,19
      IF(I.GE.8) GO TO 120
      FDATA(I,INDEX,NCAS)=A(LATLOC(I))
      FDATAC(I,INDEX,NCAS)=AC(LATLOC(I))
      GO TO 130
  120 FDATA(I,INDEX,NCAS)=B(LATLOC(I))
      FDATAC(I,INDEX,NCAS)=BC(LATLOC(I))
  130 CONTINUE
  150 NCASE(INDEX)=NCAS
      FDATA(22,INDEX,NCAS)=ALPHA
      FDATA(23,INDEX,NCAS)=MACH
      FDATAC(22,INDEX,NCAS)=PARAM
      FDATAC(23,INDEX,NCAS)=CG
      GO TO 20
 1000 FORMAT(10A4,4F10.4)
 2000 FORMAT(1H0,A4,5X,9A4,4F10.4)
      END
```

SUBROUTINE INSTR

Description: Subroutine INSTR reads plotting instructions.

Programing notes: The instructions are passed to the rest of the program in the following form:

NPLOT – number of coefficients to be plotted.

LATLON – 1 if lateral data, 2 if longitudinal data.

PARM, TOL – parameter value and tolerance.

LL – number of the predicted derivative data set corresponding to LATLON and PARM.

IDER – parameter numbers that correspond to the coefficients to be plotted.

YMIN, YMAX – minimum and maximum values for the ordinates.

Subroutine listing:

```
      SUBROUTINE INSTR
C     READS INSTRUCTIONS ON COEFFICIENTS TO PLOT,SCALES TO USE,
C          AND THE PARAMETER AND TOLERANCE FOR FLIGHT POINTS
C     DO NOT OVERLAY THIS SUBROUTINE AS START,DERIV,SMIN AND SMAX MUST
C          BE PRESERVED
      COMMON /NBPS/ NMPP,NABP,NBP,NPARAM
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG
      COMMON /INS/ NPLOT,WTPLOT
      COMMON /SELECT/ PARAM,TOL,IDER,YMIN,YMAX,LATLON,DERIVS,LL,WTPL
      REAL DERIV(4),SMIN(4),SMAX(4),DER(21,2),YMIN(21),YMAX(21),
     -     DERIVS(21),ABP(16),MBP(16),BP(8)
      INTEGER IDER(21)
      LOGICAL WTPLOT,WTPL,LONG(8)
      DATA END,ALON,ALAT,BLANK,STAR/3HEND,4HLONG,4HLATR,1H ,4HSTAR/
      DATA DER/3HCYB,3HCLB,3HCNB,3HCLP,3HCNP,3HCLR,3HCNR,4HCYDA,4HCLDA,
     -     4HCNDA,4HCYDR,4HCLDR,4HCNDR,4HCYD1,4HCLD1,4HCND1,4HCYD2,
     -     4HCLD2,4HCND2,2*1H ,
     -     3HCNA,3HCMA,3HCAA,3HCMQ,3HCNV,3HCMV,3HCAV,4HCNDE,4HCMDE,
     -     4HCADE,4HCNDC,4HCMDC,4HCADC,4HCND1,4HCMD1,4HCAD1,4HCND2,
     -     4HCMD2,4HCAD2,2HCN,2HDE/
      IF(START.NE.STAR) READ (1,1001) DERIV(1),SMIN(1),SMAX(1)
      START=STAR
      NPLOT=0
      IF(DERIV(1).EQ.END) GO TO 120
      LATLON=1
      IF(DERIV(1).EQ.ALON) LATLON=2
      NC=19
      IF(LATLON.EQ.2) NC=21
      PARAM=SMIN(1)
      TOL=SMAX(1)
      WRITE(3,2004)DERIV(1),PARAM,TOL
   20 READ (1,1001) (DERIV(I),SMIN(I),SMAX(I),I=1,4)
      IF(DERIV(1).EQ.ALAT.OR.DERIV(1).EQ.ALON.OR.DERIV(1).EQ.END)GOTO 90
      DO 70 I=1,4
      IF(DERIV(I).EQ.BLANK) GO TO 80
      NPLOT=NPLOT+1
      YMIN(NPLOT)=SMIN(I)
      YMAX(NPLOT)=SMAX(I)
      DO 30 J=1,NC
      IF(DERIV(I).EQ.DER(J,LATLON)) GO TO 60
   30 CONTINUE
      WRITE(3,2002)DERIV(I)
      STOP
   60 IDER(NPLOT)=J
   70 DERIVS(NPLOT)=DERIV(I)
      GO TO 20
   80 READ (1,1001) DERIV(1),SMIN(1),SMAX(1)
   90 WRITE(3,2001)(DER(IDER(I),LATLON),I=1,NPLOT)
  100 PARM=PARAM
      WTPL=WTPLOT
      IF(NPARAM.GT.0) PARM=0.
      DO 110 II=1,NBP
      IF((LONG(II).AND.(LATLON.EQ.1)) .OR.
     -     (.NOT.LONG(II).AND.(LATLON.EQ.2))) GO TO 110
      LL=II
      IF(PARM*BP(II)*(PARM-BP(II)).EQ.0.) GO TO 120
  110 CONTINUE
```

```
      WRITE(3,2003)                                                     INST 570
      WTPL=.FALSE.                                                      INST 580
 1001 FORMAT(4(A4,F6.0,F10.0))                                          INST 590
 2001 FORMAT(27H COEFFICIENTS TO BE PLOTTED/1X,2(A6)                    INST 600
 2002 FORMAT(1H0,A4,45H IS NOT A VALID DERIVATIVE NAME FOR THIS PLOT)   INST 610
 2003 FORMAT(30HONO WIND TUNNEL DATA AVAILABLE)                         INST 620
 2004 FORMAT(1H0,A4,6H PLOTS,5X,6HPARAM=,F10.4,5X,10HTOLERANCE=,F10.4)  INST 630
  120 RETURN                                                            INST 640
      END                                                               INST 650
```

SUBROUTINE SUMPLT

Description: Subroutine SUMPLT plots data for one derivative.

Programing notes: Most of the data manipulation has been done, and the data are ready to plot. Thus this subroutine does little except the actual plotting.

Subroutine listing:

```
      SUBROUTINE SUMPLT(FDAT,FDATC,ALFS,ND2,DATA,NBP,NMBP,NABP)
C     PLOTS SUMMARY INFORMATION FOR ONE DERIVATIVE
      COMMON /SUMDAT/ YLOC,XSKIP,ALEN,ASCAL2,YSTEP,AMIN,TABLAB,FDATA,
     -     FDATAC,TITLE
      COMMON /PSCL/ CRFACT,IWT1,IWT2,YLEN2,II,NPARAM
      COMMON /PDAT/ NOPLOT,YMN,YSCALE,NCAS,CRF,WTP,DERIV,WTD,KWT
      COMMON /WTDATA/ NCLA,NCLO,ABP,MBP,BP,NCMAX,LONG
      REAL FDAT(ND2,1),FDATC(ND2,1),ALFS(ND2,1),DATA(NBP,NMBP,1),
     -     FDATA(5000),FDATAC(5000),TABLAB(2),ABP(16),MBP(16),BP(8),
     -     TITLE(20),WTD(18,16),ABPS(18)
      INTEGER NCAS(16),ISYMB(16)
      LOGICAL NOPLOT,LONG(8),WTP
      DATA ISYMB/1,0,5,2,12,10,6,9,4,11,7,8,8,8,8,8/
      NCMX=NCMAX+2
      ND=ND2*2
      CALL PSCALE(NCMX,ND,ND2,FDATA,FDATAC,FDAT,FDATC,ALFS,DATA,NBP,
     -     NMBP,NABP)
      IF(II.NE.1) GO TO 10
      CALL PLOT(0.,-YLOC,-3)
      YLOC=0.
      CALL PLTDAT(XSKIP,12.25)
   10 IF(NOPLOT) RETURN
      KWT1=KWT-1
      J=0
      DO 15 I=IWT1,IWT2
      J=J+1
   15 ABPS(J)=ABP(I)
      ABPS(KWT+1)=AMIN
      ABPS(KWT+2)=ASCAL2
      IF(YLOC.NE.0.) GO TO 30
      CALL PLOT(XSKIP,YSTEP,-3)
      CALL SYMBOL(0.,YSTEP,.14,TITLE(1),0.,4)
      DO 20 I=2,20
   20 CALL SYMBOL(999.,YSTEP,.14,TITLE(I),0.,4)
      YLOC=YSTEP
      GO TO 40
   30 CALL PLOT(0.,-YSTEP,-3)
      YLOC=0.
   40 CALL AXIS(0.,0.,5HALPHA,-5,ALEN,0.,AMIN,ASCAL2)
      CALL AXIS(0.,0.,DERIV,4,YLEN2,90.,YMN,YSCALE)
      CALL SYMBOL(ALEN,YLEN2,.10,4HSYMB,0.,4)
      CALL SYMBOL(ALEN+.5,YLEN2,.10,TABLAB,0.,8)
      YORG=YLEN2
      DO 50 I=1,ND2
      IF(NCAS(I).LE.0) GO TO 50
      YORG=YORG-.25
      CALL SYMBOL(ALEN+.1,YORG+.07,.14,ISYMB(I),0.,-1)
      BPVAL=MBP(I)
      IF(NPARAM.GT.0) BPVAL=BP(I)
      CALL NUMBER(ALEN+.5,YORG,.14,BPVAL,0.,2)
   50 CONTINUE
C     PLOT FLIGHT POINTS
      DO 90 I=1,ND2
      NCI=NCAS(I)
      IF(NCI.LE.0) GO TO 70
      ISI=ISYMB(I)
      DO 60 J=1,NCI
```

```
      XN=(ALFS(I,J)-AMIN)/ASCAL2
      YN=(FDAT(I,J)-YMN)/YSCALE
      CALL SYMBOL(XN,YN,.14,ISI,0.,-1)
      IF(FDATC(I,J).EQ.0.) GO TO 60
      HITE=FDATC(I,J)/YSCALE
      YNH=YN+HITE
      XNP=XN+.03
      XNM=XN-.03
      CALL PLOT(XNM,YNH,3)
      CALL PLOT(XNP,YNH,2)
      CALL PLOT(XN,YNH,3)
      YNH=YN-HITE
      CALL PLOT(XN,YNH,2)
      CALL PLOT(XNM,YNH,3)
      CALL PLOT(XNP,YNH,2)
   60 CONTINUE
C     PLOT WIND TUNNEL DATA
   70 IF(.NOT.WTP) GO TO 90
      IF(NPARAM.GT.0 .AND. I.EQ.1) GO TO 80
      IF(NPARAM.GT.0 .OR. NCI.EQ.0) GO TO 90
   80 WTD(KWT+1,I)=YMN
      WTD(KWT+2,I)=YSCALE
      CALL LINES(ABFS,WTD(1,I),KWT,1,KWT1,ISI)
   90 CONTINUE
      YN=-YMN/YSCALE
      IF(YN.LE.0. .OR. YN.GT.YLEN2) GO TO 100
      CALL PLOT(ALEN,YN,3)
      CALL PLOT(0.,YN,2)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE PSCALE

Description: Subroutine PSCALE selects flight data points to be plotted on the basis of the criteria specified in subroutine INSTR. It places flight data and predicted derivatives for a single derivative into arrays for plotting and determines ordinate scales if needed.

Programing notes: Flight data are moved from arrays FDATA and FDATAC to arrays FDAT, FDATC, and ALFS. Array FDAT contains the derivative values, FDATC the confidence levels, and ALFS the angles of attack. Predicted derivatives are selected from array DATA and moved to array WTD.

Subroutine listing:

```
      SUBROUTINE PSCALE(NCMX,ND,ND2,FDATA,FDATAC,FDAT,FDATC,ALFS,DATA,
     -     NBP,NMBP,NABP)
C     DETERMINES PLOT SCALES, SELECTS DATA TO BE PLOTTED
C     DATA TO BE PLOTTED IS SELECTED FROM ARRAYS FDATA AND FDATAC
C          AND PLACED INTO THE SMALLER ARRAYS FDAT,FDATC, AND ALFS
      COMMON /CASES/ NCASE
      COMMON /PSCL/ CRFACT,IWT1,IWT2,YLEN2,II,NPARAM
      COMMON /SELECT/ PARAM,TOL,IDER,YMIN,YMAX,LATLON,DERIVS,LL,WTPL
      COMMON /PDAT/ NOPLOT,YMN,YSCALE,NCAS,CRF,WTP,DERIV,WTD,KWT
      REAL FDATA(NCMX,ND,1),FDATAC(NCMX,ND,1),FDAT(ND2,1),FDATC(ND2,1),
     -     ALFS(ND2,1),DATA(NBP,NMBP,1),YMIN(21),YMAX(21),ZSC(4),
     -     DERIVS(21),WTD(18,16)
      INTEGER IDER(21),NCAS(16),NCASE(32)
      LOGICAL WTPL,WTP,NOPLOT
      WTP=WTPL
      LONLAT=ND2*(2-LATLON)
      JDER=IDER(II)
      DERIV=DERIVS(II)
      ZSC(1)=0.
      ZSC(2)=0.
      CRF=CRFACT
      IF(JDER.GT.19) CRF=0.
      IF(JDER.EQ.21) WTP=.FALSE.
      NOPLOT=.TRUE.
      DO 90 JJ=1,ND2
      JJL=JJ+LONLAT
      NCJ=0
      NCASEJ=NCASE(JJL)
      IF(NCASEJ.LE.0) GO TO 60
      DO 50 I=1,NCASEJ
      IF( PARAM*FDATAC(22,JJL,I).NE.0. .AND.
     -     ABS(PARAM-FDATAC(22,JJL,I)).GT.TOL)  GO TO 50
      IF(FDATAC(JDER,JJL,I).LE.0.) GO TO 50
      NCJ=NCJ+1
      FDAT(JJ,NCJ)=FDATA(JDER,JJL,I)
      FDATC(JJ,NCJ)=FDATAC(JDER,JJL,I)*CRF
      ALFS(JJ,NCJ)=FDATA(22,JJL,I)
      ZSC(1)=AMIN1(ZSC(1),FDAT(JJ,NCJ)-FDATC(JJ,NCJ))
      ZSC(2)=AMAX1(ZSC(2),FDAT(JJ,NCJ)+FDATC(JJ,NCJ))
   50 CONTINUE
   60 IF(.NOT. WTP) GO TO 85
      IF(NPARAM.GT.0 .AND. JJ.EQ.1) GO TO 70
      IF(NPARAM.GT.0 .OR. NCJ.EQ.0) GO TO 85
   70 K1=(JDER-1)*NABP+IWT1
      KWT=IWT2-IWT1+1
      K2=K1+IWT2-IWT1
      J=0
      DO 80 I=K1,K2
      J=J+1
      WTD(J,JJ)=DATA(LL,JJ,I)
      ZSC(1)=AMIN1(ZSC(1),DATA(LL,JJ,I))
   80 ZSC(2)=AMAX1(ZSC(2),DATA(LL,JJ,I))
   85 NCAS(JJ)=NCJ
   90 NOPLOT=NOPLOT .AND. (NCJ.EQ.0)
      IF(NOPLOT) GO TO 110
      IF(YMAX(II).EQ.YMIN(II)) GO TO 100
      YMN=YMIN(II)
```

```
      YSCALE=(YMAX(II)-YMIN(II))/YLEN2
      GO TO 200
  100 CALL SCALES(ZSC,YLEN2,2,.FALSE.)
      YMN=ZSC(3)
      YSCALE=ZSC(4)
      GO TO 200
  110 WRITE(3,2000)DERIV
 2000 FORMAT(30HONO FLIGHT DATA AVAILABLE FOR ,A4)
  200 RETURN
      END
```

SUBROUTINES WINDIN, LOAD1, SCALES, LINES, PLTDAT, TIME, AND DATE

Subroutines WINDIN, LOAD1, SCALES, LINES, PLTDAT, TIME, and DATE are identical to those in the SETUP and MMLE program.

APPENDIX F

SAMPLE CASE FOR THE SUMARY PROGRAM

This appendix presents a sample case for the SUMARY program.

INPUT CARDS

```
SAMPLE CASE FOR SUMARY
 $WIND NCLO=6,LONG(1)=T,NABP=4,BODY=T,AMAX=24.,ASCALE=2.,CRFACT=10.,$END
CN        2
 .4          .65         .9          1.
CNA       2
 .075       .07         .065        .06
CMA       2
 -.006      -.005       -.008       -.012
CNDE      1
 .02
CMDE      1
 -.01
CMQ       2
 -5.        -5.         -5.2        -6.
 5.         10.         15.         20.
 .5
 1.
LONG   AIRCRAFT B    FLT 1 CASE 1              0.000      4.803      1.000      .260
A         3         4
  -.069730  0.000000  0.000000  -.005420
  -.005095 -5.276583  0.000000  0.000000
   .003742  0.000000  0.000000  0.000000
B         3         6
  -.008488  0.000000  0.000000  0.000000  -.346488   .076020
  -.010056  0.000000  0.000000  0.000000 -2.288757  0.000000
   .003654  0.000000  0.000000  0.000000  -.028266  0.000000
AC        3         3
   .000720  0.000000  0.000000
   .000077   .362775  0.000000
  0.000000  0.000000  0.000000
BC        3         5
   .000656  0.000000  0.000000  0.000000   .004551
   .000213  0.000000  0.000000  0.000000   .000825
  0.000000  0.000000  0.000000  0.000000  0.000000
LONG   AIRCRAFT B     FLT 1  CASE 4            0.000     10.031      1.000      .260
A         3         4
  -.068788  0.000000  0.000000  -.016320
  -.004044 -6.148364  0.000000  0.000000
   .006651  0.000000  0.000000  0.000000
B         3         6
  -.006378  0.000000  0.000000  0.000000  -.653271   .115600
  -.010248  0.000000  0.000000  0.000000 -5.328408  0.000000
   .002856  0.000000  0.000000  0.000000  -.011942  0.000000
AC        3         3
   .001169  0.000000  0.000000
   .000086   .433856  0.000000
  0.000000  0.000000  0.000000
BC        3         5
   .001016  0.000000  0.000000  0.000000   .013379
   .000192  0.000000  0.000000  0.000000   .001911
  0.000000  0.000000  0.000000  0.000000  0.000000
LONG   AIRCRAFT B    FLT 1  CASE 8             0.000     13.671      1.000      .260
A         3         4
  -.051724  0.000000  0.000000  -.026070
  -.005240 -2.218513  0.000000  0.000000
   .005995  0.000000  0.000000  0.000000
B         3         6
  -.019702  0.000000  0.000000  0.000000  -.813778   .112380
  -.009046  0.000000  0.000000  0.000000 -6.745284 -0.000000
   .002492  0.000000  0.000000  0.000000  -.002600  0.000000
AC        3         3
   .001280  0.000000  0.000000
   .000044   .296974  0.000000
  0.000000  0.000000  0.000000
BC        3         5
   .001391  0.000000  0.000000  0.000000   .020161
   .000202  0.000000  0.000000  0.000000   .001633
  0.000000  0.000000  0.000000  0.000000  0.000000
```

```
LONG    AIRCRAFT B     FLT 1    CASE 11          0.000     16.399      1.000        .260
A          3          4
   -.058530  0.000000  0.000000  -.012960
   -.008326 -2.095303  0.000000  0.000000
    .005033  0.000000  0.000000  0.000000
B          3          6
   -.013062  0.000000  0.000000  0.000000  -.935426   .120320
   -.010224  0.000000   .000046  0.000000 -8.717713 -0.000000
    .002516  0.000000  0.000000  0.000000   .002881  0.000000
AC         3          3
    .001301  0.000000  0.000000
    .000051   .219645  0.000000
   0.000000  0.000000  0.000000
BC         3          5
    .001209  0.000000  0.000000  0.000000   .023573
    .000147  0.000000  0.000000  0.000000   .001681
   0.000000  0.000000  0.000000  0.000000  0.000000
LONG    AIRCRAFT B     FLT 1    CASE 12          0.000     17.993      1.000        .260
A          3          4
   -.066610  0.000000  0.000000  -.015460
   -.007499 -4.851715  0.000000  0.000000
    .005784  0.000000  0.000000  0.000000
B          3          6
    .001381  0.000000  0.000000  0.000000 -1.008667   .171330
   -.011126  0.000000  0.000000  0.000000 -9.911981 -0.000000
    .002070  0.000000  0.000000  0.000000   .004800  0.000000
AC         3          3
    .001335  0.000000  0.000000
    .000056   .222093  0.000000
   0.000000  0.000000  0.000000
BC         3          5
    .001252  0.000000  0.000000  0.000000   .027691
    .000157  0.000000  0.000000  0.000000   .002271
   0.000000  0.000000  0.000000  0.000000  0.000000
LONG    AIRCRAFT B     FLT 1    CASE 15          0.000     20.088      1.000        .260
A          3          4
   -.061936  0.000000  0.000000  -.003870
   -.010069 -3.778632  0.000000  0.000000
    .006358  0.000000  0.000000  0.000000
B          3          6
   -.006655  0.000000  0.000000  0.000000 -1.085620   .148190
   -.011583  0.000000  0.000000  0.000000-11.977400 -0.000000
    .001551  0.000000  0.000000  0.000000   .012342  0.000000
AC         3          3
    .001470  0.000000  0.000000
    .000073   .254969  0.000000
   0.000000  0.000000  0.000000
BC         3          5
    .001046  0.000000  0.000000  0.000000   .030336
    .000171  0.000000  0.000000  0.000000   .002594
   0.000000  0.000000  0.000000  0.000000  0.000000
LONG    AIRCRAFT B     FLT 1    CASE 17          0.000     21.376      1.000        .260
A          3          4
   -.055533  0.000000  0.000000  -.008290
   -.011031  -.436157  0.000000  0.000000
    .006307  0.000000  0.000000  0.000000
B          3          6
   -.015876  0.000000  0.000000  0.000000 -1.154961   .164710
   -.008337  0.000000  0.000000  0.000000-13.301825 -0.000000
    .001350  0.000000  0.000000  0.000000   .011709  0.000000
AC         3          3
    .001023  0.000000  0.000000
    .000039   .133743  0.000000
   0.000000  0.000000  0.000000
BC         3          5
    .000712  0.000000  0.000000  0.000000   .021764
    .000086  0.000000  0.000000  0.000000   .001495
   0.000000  0.000000  0.000000  0.000000  0.000000
```

```
LONG    AIRCRAFT B     FLT 1    CASE 19          0.000      22.641      1.000       .260
A           3          4
   -.057218  0.000000  0.000000  -.005510
   -.011844   .165115  0.000000  0.000000
    .006115  0.000000  0.000000  0.000000
B           3          6
   -.012764  0.000000  0.000000  0.000000 -1.187400   .185320
   -.007307  0.000000  0.000000  0.000000-15.322314 -0.000000
    .001150  0.000000  0.000000  0.000000   .012945  0.000000
AC          3          3
    .001052  0.000000  0.000000
    .000060   .161152  0.000000
   0.000000  0.000000  0.000000
BC          3          5
    .000772  0.000000  0.000000  0.000000   .025420
    .000118  0.000000  0.000000  0.000000   .002325
   0.000000  0.000000  0.000000  0.000000  0.000000
PLOT
LATR
CNB
LONG
CN                 CNA                CMDE               CNDE
CMA                CMQ                DE                 CMDC
END
```

OUTPUT LISTING

```
MMLE SUMMARY PLOTTING PROGRAM     ****   1 JULY 1974     ****    VERSION 2

                    SAMPLE CASE FOR SUMARY

CONFIDENCE LEVELS WILL BE PLOTTED MULTIPLIED BY 10.0

LONG          AIRCRAFT B    FLT 1 CASE 1          0.0000    4.8030    1.0000    .2600

LONG          AIRCRAFT B     FLT 1  CASE 4        0.0000   10.0310    1.0000    .2600

LONG          AIRCRAFT B    FLT 1  CASE 8         0.0000   13.6710    1.0000    .2600

LONG          AIRCRAFT B    FLT 1   CASE 11       0.0000   16.3990    1.0000    .2600

LONG          AIRCRAFT B    FLT 1   CASE 12       0.0000   17.9930    1.0000    .2600

LONG          AIRCRAFT B    FLT 1   CASE 15       0.0000   20.0880    1.0000    .2600

LONG          AIRCRAFT B    FLT 1   CASE 17       0.0000   21.3760    1.0000    .2600

LONG          AIRCRAFT B    FLT 1   CASE 19       0.0000   22.6410    1.0000    .2600

LATR PLOTS      PARAM=    -0.0000      TOLERANCE=    -0.0000
COEFFICIENTS TO BE PLOTTED
CNB

NO WIND TUNNEL DATA AVAILABLE

NO FLIGHT DATA AVAILABLE FOR CNB

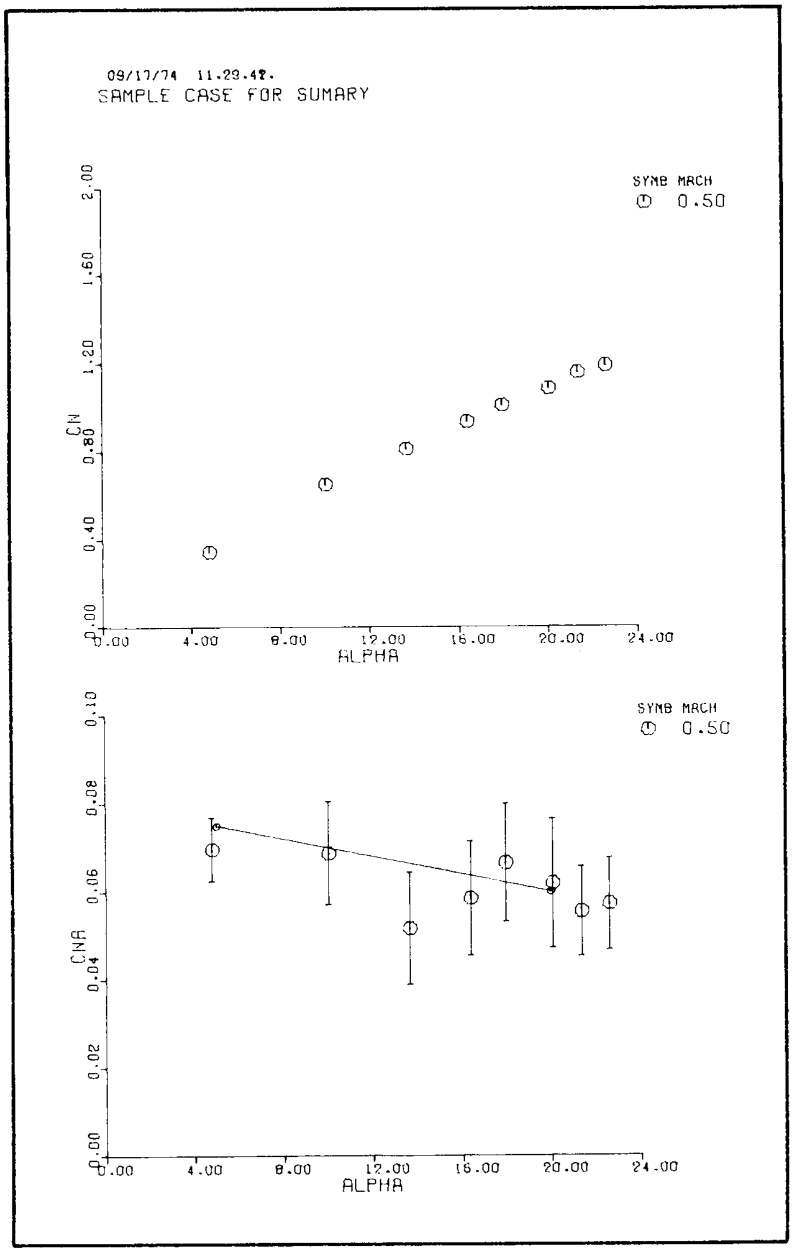
LONG PLOTS      PARAM=    -0.0000      TOLERANCE=    -0.0000
COEFFICIENTS TO BE PLOTTED
CN     CNA    CMDE  CNDE  CMA    CMQ    DE     CMDC

NO FLIGHT DATA AVAILABLE FOR CMDC
```

A sample plot from the SUMARY program is shown. The plot is presented in four parts to avoid loss of detail from a large reduction. The plot as produced by the automatic plotter is shown within the heavy lines. Explanatory material is included to aid the user in implementing the program. Solid lines denote predicted derivatives. Vertical bars (I) indicate confidence levels.

C_N

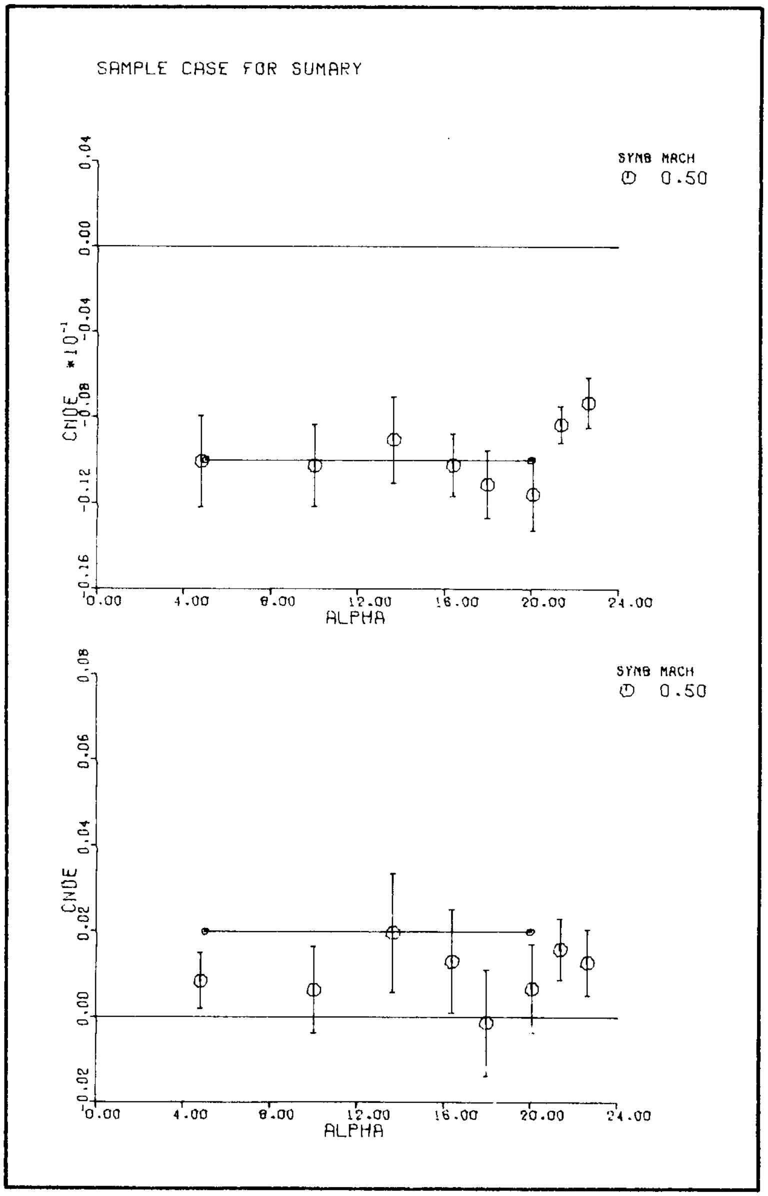
C_{N_α}



α

$C_{m_{\delta_e}}$

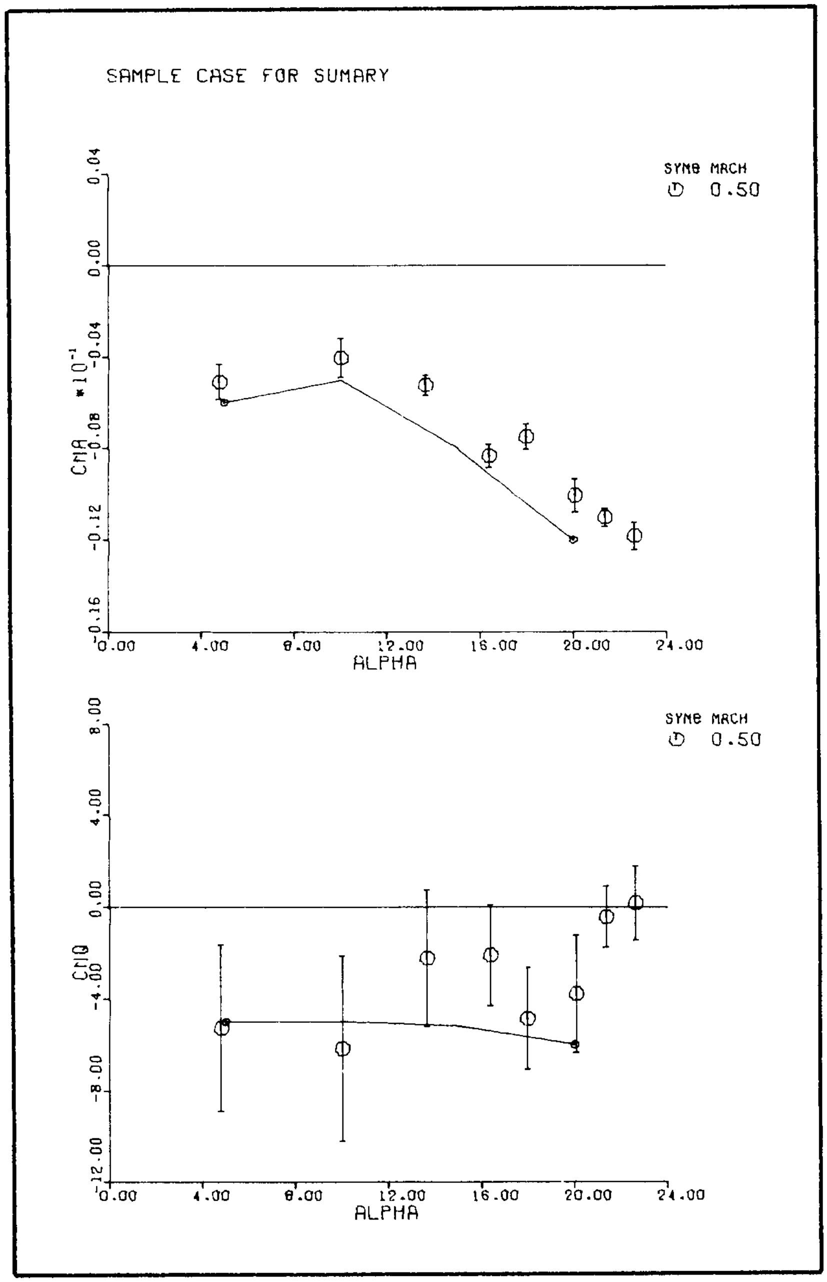
$C_{N_{\delta_e}}$



α

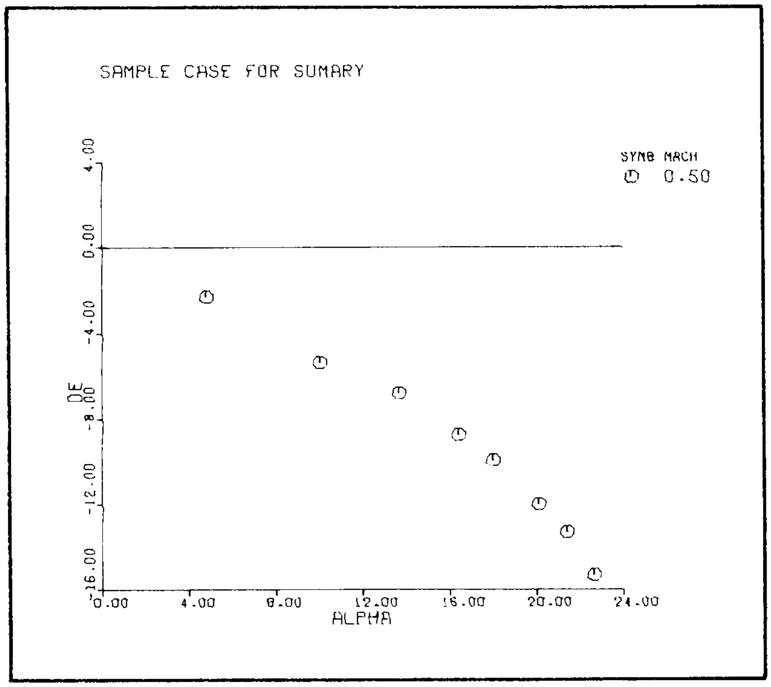
C_{m_α}

C_{m_q}



α

$\delta_{e_{trim}}$



α

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